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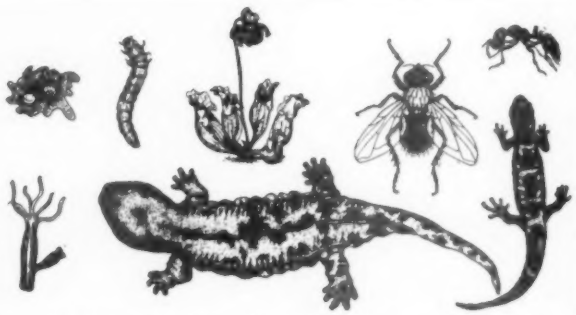
Teaching Biology with Living Things



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SCHOOL SCIENCE AND MATHEMATICS

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THE 1940 CONVENTION

NOVEMBER 22 AND 23, 1940

The convention in Cleveland this year will be organized along much the same lines as the recent very successful convention programs. Arrangements are nearing completion as this statement goes to the editor.

The convention theme for 1940 is "Science and the Citizen." All of the general and sectional programs are pointed in the direction of the convention theme. An eminently outstanding industrial research director will discuss research and the citizen at the first general session. Other topics at this general meeting will include a paper dealing with adolescent growth and development in their relation to education, and another which points up the impact of mathematics on the social sciences. Also of general interest is an illustrated talk on rare bird life. The illustrations will be kodachrome movies of forms not previously photographed in color. These films have just been finished, and will be given their first public showing at our convention.

Strong programs have been prepared by the sectional chairmen. Biology will have a combined meeting with the Greater Cleveland Biology Society. Chemistry will have a research expert, and a panel discussion by members of a recent chemistry education workshop. Improved materials and methods will hold the center of attention in the Elementary Science Section. General Science will present a weather expert who will explain long range forecasting from mass air movements, along with other worth while numbers. The Mathematics Section will hear further of the importance of this area in relation to social phenomena, and will also have an outstanding leader in mathe-

matics education on the program. The Physics Section is prepared to hear a discussion of improved laboratory demonstrations, along with a paper on the latest discoveries in this field.

A luncheon meeting of the Geography Section is a special feature of this year's convention. This luncheon has been arranged by the Conservation Committee of the Association. The annual dinner will be up to standard with an illustrated program. The demonstrations and lectures by exhibitors, which have proved a popular feature at the last two conventions, will be continued again this year

The local arrangements committees have worked hard in preparing the details of this program For those who are up to date in their science and mathematics teaching, and who wish to continue to be so, this convention should be on the MUST list

NATHAN A. NEAL, *President*

ALIEN REGISTRATION DIVISION OF IMMIGRATION AND NATURALIZATION SERVICE DEPARTMENT OF JUSTICE

As part of the National Defense program, the nationwide registration of aliens will be continued through December 26, 1940, by the Immigration and Naturalization Service of the Department of Justice. Registration will take place in the post offices of the nation.

Registration is made compulsory by a specific act of Congress, the Alien Registration Act of 1940, which requires all non-citizens to register during the official registration period. The law requires that all aliens 14 years or older are to be registered and fingerprinted. Alien children under 14 years of age will be registered by their parents or guardians. When alien children reach their fourteenth birthday, they will be required to register in person and be fingerprinted.

A fine of $1,000 and imprisonment of six months is prescribed by the Alien Registration Act for failure to register, for refusal to be fingerprinted, or for making registration statements known to be false.

As part of its educational program to acquaint non-citizens with the registration requirements, the Alien Registration Division is distributing more than five million specimen forms listing the questions that will be asked of aliens at registration time. Besides the usual questions for establishing identification, the questionnaire asks the alien to tell how and when he entered the country, the method of transportation he used to get here, the name of the vessel on which he arrived.

He is also asked to state the length of time he has been in this country and the length of time he expects to stay. He must also describe any military or naval service he has had, and list the names of any organizations, clubs, or societies in which he participates or holds membership. In addition, he is required to describe his activities in any organization, and to affirm whether or not the organization furthers the interests or program of a foreign government.

SCIENCE AND HUMAN WELFARE*

JAS. K. HUNT
E. I. du Pont de Nemours & Company, Wilmington, Delaware

During the past few years much has been written and said about the social implications of scientific developments. I am reminded of the discouraged young poet who wrote as follows:

> If all the poems I have written
> Were piled up in a pile
> And with a match were litten
> You could see the blaze a mile.
>
> But all the gold that I have gitten
> For the poems I have wrote
> Would not hurt the feeblest kitten
> If poured molten down its throat.

The blaze that would be created by all that has been written in recent years regarding the social implications of scientific progress could probably be seen ten miles, and as a matter of fact, part of that which has been written on this subject should, in my opinion, be reduced to ashes. I, for one, would enjoy watching the blaze.

I have reference to the writings of those who look with such misgivings on the social value of scientific and technological developments as to suggest a holiday for the chemist, physicist, and other workers in the field of science.

As you doubtless know, there are some who would blame science for most, if not all, of our present social, economic and industrial ills, and even for war. They overlook the horrible wars that were waged 2,000 years ago, when there was no science as we know it today. They appear to forget that man is, by nature, a perverse creature, and that it is only through education, that is, education of the proper sort, and moral training, that we become sufficiently civilized to live in peace and harmony with our fellows. These misguided, although possibly sincere, individuals realize that something is wrong with the world, and have decided to make science the scapegoat. They fail to see, or at least to appreciate, that scientific research has opened up thousands of new jobs; increased our national wealth by untold millions; conserved our natural resources; aided in wiping out ignorance, superstition, and disease; contributed to

* Based on talk delivered before the All-Science Section of Wisconsin Education Association, Milwaukee, Wisconsin, November 2, 1939.

our comfort and happiness; and last, but by no means least, provided leisure for the enjoyment of the better things created through scientific research.

All scientific progress, of course, makes for better living. For the sake of brevity, however, let us consider only those advances which have very obvious social implications. This includes developments which promote industrial welfare, since social progress is dependent in no small degree upon industrial welfare. Among these developments having very obvious social implications we should certainly include those which, like the incandescent lamp, telegraph, telephone, radio and motion pictures, facilitate the dissemination of knowledge. We must include also those developments which aid in satisfying our inherent love of beauty, and the desire for wholesome recreation; those which open up new avenues of employment, yet provide sufficient leisure for proper cultivation of the body, mind and soul; those which promote safety and health; and finally, those developments which contribute to our national self-efficiency.

Scientific developments cannot always be sharply classified in terms of their social effect. The radio, for example, not only aids in the dissemination of knowledge, but also is capable of bringing us beauty in the way of symphonic music. In addition, the radio affords wholesome recreation, to the poor as well as the rich. Furthermore, the radio industry, although only 20 years old, has more than 15,000 persons on its payroll who receive almost $27,000,000 a year. Likewise, motion pictures are not only of educational value, but of recreational value as well.

Progress in the field of chemistry has contributed much that is both useful and beautiful. Our parents can remember when only the fortunate few could afford clothing made of silk. Today, thanks to the development of rayon, millions of girls on a limited budget dress better than did Cleopatra, or the Queen of Sheba.

Of interest in this connection, particularly to women, is the recent development of nylon, a new synthetic organic compound derived basically from coal, air, and water, which is so versatile that the extent of its possible commercial uses can only be guessed today. Among other things, textile filaments can be made from this new synthetic product which are stronger and more elastic than any fiber now in general use, whether cotton, linen, wool, rayon, or silk. Because of its superior strength and

elasticity, one of the first important applications for nylon thread or yarn will be in the manufacture of fine hosiery.

Likewise of particular interest to women are the chemicals which render fabrics resistant to creasing and wrinkling. Velvets, for example, are now made which may literally be walked upon without permanently crushing the pile. The chemist has provided many other materials which improve the quality of fabrics, or aid in their preservation, including moth repellents, mildew inhibitors, and, quite recently, a durable water-repellent finish which renders the finest fabrics resistant to spotting by rain, or carelessly spilled beverages such as coffee, tea, and fruit juices.

Since dyestuffs are frequently taken for granted, it may be in order to remind you that the somber and fugitive natural dyes known to our parents have given way to a complete rainbow of bright fast colors, derived from coal tar, including one which far surpasses in brilliance and fastness even the royal purple of antiquity.

Beautiful china and glassware, largely imported until a few years ago, and available only to the comparatively well-to-do, can now be had by all, thanks to progress in the field of ceramics, particularly the development by American chemists of bright, fast ceramic colors.

Synthetic plastics have also enriched our lives by making available a wide variety of beautiful, yet inexpensive, articles, —toiletware, costume jewelry, etc., formerly made from such relatively costly materials as ivory, jade, tortoise shell, and amber.

Since camphor is extensively used in the manufacture of nitrocellulose plastics, including photographic and motion picture film, as well as in medicine, the development of synthetic camphor has great social implications.

Until a few years ago, this material came from the camphor trees of Formosa, owned by Japan. The Japanese controlled the world market, and with it, the price. But in recent years, chemists worked out a process by which turpentine from our southern pine trees is converted into camphor chemically identical with that obtained from the trees of far-away Formosa. Using this domestic product as raw material, the Du Pont Company is today producing more than half our total domestic consumption of camphor, and, if necessary, additional plant capacity could be provided to take care of our entire

domestic requirements, thus eliminating dependence on Japan.

As recently as 1920, refined imported natural camphor reached $3.55 a pound; today, refined synthetic camphor sells for around 60¢ a pound. The technical grade, however, used in the manufacture of photographic film and nitrocellulose plastics, sells for about 35¢ a pound. The significance of this development is indicated by the fact, that, in the manufacture of motion picture film alone, this country consumes annually some 600,000 pounds of camphor.

So much has been said recently regarding the influence of technological advances on employment that there is little new to say on this subject. I wish only to point out that 15 industries, developed since 1879, have created approximately 15,000,000 new jobs. Accordingly, at least one out of every 4 persons gainfully employed today, owes his job to some one of these 15 industries having their origin wholly or in part in developments resulting from scientific research. In this connection you may be interested to know that today some 32,000 technically trained workers find employment in research laboratories alone, of which this country has more than 1,700, and that industry's annual appropriation for research is of the order of $250,000,000. While $250,000,000 sounds like a large sum of money, we actually spend more than this each year on cosmetics.

As regards so-called technological unemployment, it might also be pointed out that during the period of most intensive technological development this country has ever experienced, 1900–1930, an estimated 42 new jobs were created per 100 persons added to our population. The significant point is that only around 40 persons out of each 100 of our total population ever seek gainful employment.

Through progress in the development and application of mechanical power, man has been released from the drudgery of a generation or two ago. The Machinery and Allied Products Institute has shown that to earn a year's supply of clothing for a family of four, plus an automobile, and eight representative items for the home, the average factory laborer had to work only about one-third as many hours in 1936, as in 1914. The real problem confronting many today is not so much securing leisure, as it is utilizing leisure to the best advantage.

Scientific progress has contributed greatly to our comfort and safety. For the air-conditioning of homes, theaters and office buildings, as well as for use in domestic refrigerators, science

has developed a new class of refrigerants, which are non-poisonous, non-explosive, and non-flammable.

One of the major hazards of motoring was greatly reduced through the development of safety glass, made by sandwiching a sheet of transparent plastic between two pieces of plate glass. A recent contribution to safe driving at night is the development of a transparent plastic used in making reflectors for use on highways. Specially designed buttons of this plastic, mounted at 100-foot intervals along the edge of the road, reflect the light from one's headlamps, thus clearly outlining the highway, and showing what lies ahead in the way of curves.

Fire-retardant chemicals for textile fabrics represent another scientific development that contributes to safety. A new chemical recently introduced renders dress goods and curtain fabrics absolutely flame-proof, without changing the shades of dyes or affecting the feel of the fabric.

Scientific developments have played an extremely important role in the prevention and cure of disease. You are familiar, of course, with the brilliant work of Louis Pasteur in the field of serum therapy, and the achievements of Ehrlich in the field of chemo-therapy. Fortunately for mankind, others have carried on from where Pasteur and Ehrlich left off. The coal-tar derivative known as sulfanilamide, although introduced into the field of medicine only a few years ago, has already saved the lives of thousands suffering from "blood-poisoning," and other dangerous maladies due to streptococcic infection. And more recently a related compound, sulfapyridine, has shown great promise in the treatment of pneumonia, which claims annually a toll of some 100,000 lives in the United States.

As a result of progress in the fields of bio-chemistry, medicine, and nutrition, such deficiency diseases as rickets, scurvy, and pellagra can now be cured or prevented, and I confidently expect the sister sciences of chemistry, physics, biology and medicine to point the way to the prevention or cure of such diseases as cancer, which is responsible for some 135,000 deaths each year in this country.

The research chemist has established the constitution of, and synthesized, certain of the hormones, those little-understood secretions of the ductless glands which in some mysterious way regulate the functioning of the mind as well as the body. Developments in this field offer definite promise for the cure of mental ills which have baffled medical science for ages.

But scientific advances have resulted in something else, which, in my opinion, is of the most vital importance, particularly at this time. Through the low-hanging war clouds which threaten to envelop a large part of the world, there shines at least one beam of light for which we in this country should be supremely grateful: Today, thanks to scientific developments of the past 25 years, America is largely independent of foreign sources of supply for materials vital to industry, to the national defense, to life itself. I say this is of vital importance because I feel that self-sufficiency makes for peace.

In this connection I should like to quote from a paper by Dr. Karl T. Compton, President of the Massachusetts Institute of Technology, before the American Chemical Society last fall in Boston:

> Insofar as wars are caused by the natural "cussedness" of human nature, science can contribute, if at all, only indirectly. It can probably not do much toward removing the desire which some men have for great domination. It cannot remove ambition and envy from the human breast. But insofar as wars may be induced by economic considerations, science may do much to remove the causes.
>
> Science has given mankind a method of gaining the good things without taking them from someone else, and without working inordinately long and hard to produce them. Discovery and development of the good things of life by science, engineering and invention are a far more certain and productive source than organized loot and robbery. To the extent, therefore, that great groups of people, such as nations, can be induced to support technological development directed toward these ends, to that extent can they satisfy their desires without recourse to war.

I think it might be of interest to consider briefly our present degree of national self-sufficiency.

Many of you will doubtless recall the situation that obtained in this country 25 years ago when war broke out in Europe. Then, many of our industrial activities were dependent upon imports. Employment of millions of our workers was threatened, particularly in the textile industry, which was almost wholly dependent upon foreign-made dyestuffs. Even the health of our people was endangered because the importation of many important medical supplies had been cut off. Conditions bordered on panic.

Today, in sharp contrast, practically every important American industrial and medicinal need is being filled, and, I am confident, will continue to be filled, by American factories on American soil, whatever emergency may arise from the present European conflict. This is due in no small degree to the accomplishments of scientific research during the past two decades.

It is fitting that we consider conditions then and now. In 1914, this country did not have a single plant for extracting nitrogen from the air, and transforming this element into the nitrates and other chemicals so vital to agriculture, industry, and the national defense. Then, we were almost completely dependent upon the importation of natural nitrates from Chile. Although America is not wholly self-sufficient in respect to fixed nitrogen, today huge plants produce a large part of the nation's industrial and agricultural requirements, and if necessary these plants can be expanded to meet all our needs.

Similarly, the United States produced less than 10% of the dyes it consumed a quarter of a century ago, and even that meager proportion was made from imported intermediates. Today, the American dye industry produces about 95% of our total domestic consumption, and has an export balance. A great organic chemicals industry that has come into being is supplying all but a trifling fraction of the country's needs, not alone in dyes, but in other fine chemicals as well. It produces needed medicinals in abundance. There is no longer any cause for worry over war abroad curbing our supply of drugs.

When the World War began, the United States was almost wholly dependent upon Germany for potash, which is essential to agriculture and industry. In recent years methods have been devised for the economic recovery of potash from our own mineral deposits. We now produce a major part of the potash we consume, and if necessary we can produce all we need.

Another essential material is rubber, imported from far-away lands, under foreign control. It presented a grave problem during the World War, as supplies dwindled, and prices rose. This need not happen now. Neoprene, the chemical rubber made from domestic raw materials—coal, limestone and salt—has every promise of functioning satisfactorily in place of natural rubber.

In 1914, America likewise was dependent upon Europe for the fine optical glass needed in the manufacture of various instruments, vital alike in peace or war. Today, thanks to research by American scientists, this country is producing optical glass of a quality second to none in the world.

Camphor, used in the manufacture of plastics and photographic film, as well as in medicine, was the instrument of a foreign monopoly 25 years ago. That monopoly has long since been broken. As was previously pointed out, camphor is now

produced synthetically, at home, from southern turpentine.

There was no synthetic equivalent for natural bristles in 1914. This country was then dependent upon shipments it could get from the far corners of the globe. Nylon, the new synthetic material to which I referred previously, not only gives textile yarns of superior strength and elasticity, but also bristles, better than any taken from the hogs of the Orient.

These are but a few examples of the hundreds of accomplishments achieved by scientific research since the Great War. Our diversified chemicals industry, which did not exist in 1914, is well organized, well equipped, well manned today. It stands as a solid guarantee of American self-sufficiency. Never again will the orderly course of our industrial life which depends upon chemistry be disrupted by wars beyond our borders. Never again will our people be deprived of many vital medicinals for the preservation of health.

It isn't sufficient, however, for you, as science teachers, to know that scientific developments have far-reaching social implications. And here I come to my real thesis. It is my contention that the function of the science teacher is not simply to teach the bare facts of science, but also to lead his or her students to see, and appreciate, the underlying social implications of scientific advances. Failure to appreciate these social implications is responsible for much of the loose talk today about the so-called evils of science and technology.

Possibly my pedagogical ideas are old-fashioned, but I fear that some teachers unduly emphasize subject matter, at the expense of the more important ethical and social aim of all teaching, which, in my opinion, is to build character. In this connection I should like to quote from a paper by Dr. Edwin Grant Conklin, Professor Emeritus of Biology at Princeton University, before a recent meeting of science teachers in New York City:

> We have put too much emphasis upon the details of our teaching, and have had too little vision of the ultimate aims of our teaching. How long will the students remember the things you teach them? Yet they carry away the example that you are setting them, the spirit of your teaching, and most of all, they carry away the habits they have acquired while you have been teaching them.
>
> Science is not responsible for our ills, but human nature is. Science is purely altruistic, working for the good of man, for a more abundant life in every way. Science is showing the way in which society should progress.

"Science," he added, "teaches the spirit of tolerance, of fair

play, and of cooperation. Then why, in certain countries where science is greatly advanced, are not these ideas fulfilled?" he asked. One reason, according to Professor Conklin, is the approach taken by the science teacher who has emphasized the subject, and neglected the student.

I am quite willing to grant that the world is sick, but the industrial, economic and social ills of the world are not to be cured by a scientific holiday, as has been suggested. This is the cowardly philosophy of defeatism, and is doomed to certain failure. It is not science, but the weakness of human nature, that is responsible for the evils of the world.

Instead of declaring a scientific holiday, I say that still more knowledge needs to be developed. I do not, however, have reference simply to more knowledge in the physical sciences, but also more knowledge in the social sciences. The physical scientist has shown, among other things, how an abundance of goods can be produced, but we are still faced with the serious problem of the distribution of these goods, and this important problem logically belongs in the domain of the social sciences. Possibly the physical scientist should give more consideration to problems of this type.

In closing I should like to leave this one thought with you, if no more. Although there is need for the development of further knowledge in both the physical and social sciences, the crying need is for a development of a sense of moral responsibility regarding the proper use of this knowledge, and I hold that it is very definitely a part of the teacher's job to aid in developing this sense of moral responsibility. Man's inhumanity to man may at times arise from the abuse of scientific knowledge, but never from its legitimate or intended use.

HARMLESS AMOUNTS OF ALUMINUM DISSOLVED FROM PANS

Fears that acid foods may dissolve harmful amounts of aluminum from a cooking utensil made of that metal were dispelled by Dr. Charles F. Poe, and Janett Leberman of the University of Colorado. Acid foods, juices of fresh and canned fruits, were each cooked in such utensils for 30 minutes and the increase in amount of aluminum measured. It was found that solution was higher in die-cast utensils than in spun ones. Rhubarb showed the greatest effect, but even this in the die-cast pan, dissolved only a fortieth of one percent of its own weight. Others were much less.

"The amounts of aluminum dissolved by the acid food from the cooking utensils were so small that, according to most authorities, they would have no physiological effect on the body," the report stated.

BROOKLYN BOTANIC GARDEN'S COOPERATION WITH PUBLIC SCHOOLS*

C. STUART GAGER
The Brooklyn Botanic Garden, Brooklyn, New York

The Brooklyn Botanic Garden, like all the museums of Greater New York, is maintained in part by appropriations in the Tax Budget of the City and in part by private funds. For a number of years the private funds budget has somewhat exceeded 50% of the total annual budget of the Garden. The City owns the land and buildings, although part of the cost of the buildings and of the development of the plantations and grounds has been met from private funds. All plants are purchased from private funds. The Garden is administered by a private Board of Trustees. The Mayor, the Comptroller, and the Park Commissioner are *ex officio* members of this Board. The scientific, educational, and maintenance personnel are employees of the Board and not of the City.

The *Agreement* between the Board and the City provides that the Garden shall, so far as surplus allows, provide plant material for the botanical and nature study work of the schools, but from the beginning the Garden has offered extensive cooperation with the public and private elementary, junior high, and high schools and colleges of the City, as well as with the Department of Parks, Department of Health, and other City departments.

The program of the Garden has been announced as including anything scientific or educational based upon plant life, and educational opportunities offered to both adults and children, extending from children's gardening and nature study with plants to graduate work for advanced degrees. The adult education program does not include work of the nature of undergraduate college courses, except that a course in general botany, with laboratory work, is given each year.

The purpose of the Garden, in its relation to the schools, is to supplement and enrich the school work by instruction, demonstration methods, the supply of study material which would not otherwise be easily available in a great city, by personal and group conferences with teachers, and by popular

* Invited paper, given before the American Science Teachers' Association at its annual meeting at Columbus, Ohio, on December 28, 1939.

leaflets, outlines and syllabi, distributed free to teachers at irregular intervals.

The educational activities fall into one or the other of two groups: Work conducted independently of the schools; work in cooperation with the schools, for both teachers and pupils. The Botanic Garden recognizes the educational advantages of illustrated lectures to large audiences of children, especially of motion picture lectures, but it believes that the most substantial results are to be obtained by dealing with comparatively small groups or classes of from twenty-five to fifty, and most of the work is organized on that basis. This involves, of course, the sacrifice of more imposing figures of attendance.

As in the case of museums, the educational work is largely based on the labeled collections, outdoors and in the conservatories. Our work with schools falls naturally under various heads, as follows:

The Botanic Garden as a Whole

Plantations and Conservatories. These correspond to the exhibits installed in the galleries of museums. The plantations of a botanic garden differ from those of an ordinary park in the fact that they are classified on a botanical basis and carefully labeled, so that they serve not only an aesthetic but also an informational purpose. It is an almost daily sight to see classes with their teachers from the schools (as well as garden clubs, girl scouts, boy scouts, and other groups) visiting the plantations and copying the labels while instruction is being given by the teacher. Recently classes have been taken to the botanic garden and museums in charge of WPA guides.

Docentry. A docent is a *teaching guide*—one who does much more than show people about. The Botanic Garden offers free docentry service to classes from all grades of public and private schools, and the demand for this service tends to increase. As a rule, the "field work" is preceded by a perparatory talk in the class room or auditorium, and care is taken, so far as possible, to see that the teacher does "follow-up" work after the class returns to the school. In fact, everything possible is done to insure that the visit to the Botanic Garden does not degenerate into a mere outing, but yields educational returns sufficient to justify the time and trouble and expense involved in bringing the class to the Garden, often from a distance of many miles, as, for example, when classes come from a school as far as Staten Island.

The teachers, and often each pupil, are commonly supplied with syllabi covering the subject of the lesson given by the docent at the Garden.

Work Centering at the Schools

Talks. The principals or teachers of public and private elementary and high schools and colleges may arrange to have talks given at the school by members of the Garden staff. These *extramural* talks to schools now average about twenty-five a school year, with a total attendance of more than 11,000. From time to time, "model" lessons are given by a member of the Garden teaching staff at schools before several classes with their teachers assembled at the same time and place.

Loan Lectures. Sets of lantern slides in color are made up in lecture sets for loan to schools. Each set is accompanied by typewritten lecture text.

Seeds for School and Home Planting. Penny packets of flower and vegetable seeds are put up by the Botanic Garden for planting in school and home gardens. About one million of these packets are supplied each year.

Living Plant Distribution

Plants Raised in Classes. Many courses in plant propagation and related subjects are given in the instructional greenhouses for both children, and teachers, and other adults. Pupils in these classes are given the plants they raise. The number distributed in this way in 1938 was nearly 42,000 to more than 1,600 pupils, representing 142 schools.

Potted plants are placed in school rooms, chiefly to beautify the room, to the number of several hundred a year. This is in addition to the potted plants supplied for study purposes.

Study material is supplied to high and junior high schools, elementary schools, and colleges in large quantities. During 1939, living plants and plant parts, mounted plants, Petri dishes with sterilized agar, and other study material were supplied to more than 4,500 teachers for the instruction of more than 300,000 pupils.

School Classes at the Garden

School classes come to the Garden with their teachers, by appointment, for illustrated lectures by a member of the Garden staff, or for guided tours of instruction through the con-

servatories and the outdoor Plantations. This work is planned for correlation with the New York City school syllabi in nature study, biology, and geography. Art classes meet constantly in the Garden for sketching. The Garden equipment, including plant material, lecture rooms, and class rooms, lanterns and slides, is at the disposal of teachers who desire to instruct their own classes at the Garden, but such work is largely confined to outdoor lessons. About 50,000 pupils now visit the Garden annually with their teachers for instruction.

Miscellaneous Items

The Library of the Garden, open free to the public daily, is used extensively by pupils of all grades of public and private schools and colleges, and the services of the Library staff are freely at the disposal of readers.

Conferences with teachers are held throughout the year. Hundreds of teachers confer with members of the Garden staff each year concerning their problems in nature study, biology, and other subjects.

A Boys and Girls Club was organized several years ago, and comprises several hundred children of school age, with their own officers and with meetings held in a special children's room at the Garden and in the children's building at the Children's Garden.

The Children's Garden work is organized independently of the schools. About 200 boys and girls have individual and partnership gardens. The entire work in this garden is organized primarily as an educational discipline, the crop of vegetables and flowers being considered by the instructors as a secondary result of the work.

No charge is made to classes from the schools, but teachers pay a nominal fee to help meet the cost of the large quantities of material used and taken home.

All children in classes organized apart from the schools pay a nominal fee—e.g., twenty-five cents for a plot in the Children's Garden with seeds, tuition, and all the crop they raise to take home. The attendance at classes organized independently of the schools averages about 50,000 a year, making a total attendance (including school classes) of about 100,000 a year.

Continuity of attendance is one of the most important aspects of the work with children. Many boys and girls come to the

Garden voluntarily for instruction on Saturdays, during vacation time, and out of school hours for as many as three and four consecutive years. Several boys and girls have been in constant attendance for as many as seven years, going from here into some aspect of plant work, as commercial florists or nurserymen, or into scientific and educational work, attaining the doctor's degree with botany as a major and becoming teachers in preparatory schools and colleges, or going into the forest service or other scientific positions.

EARTH HISTORY FIELD CONFERENCES—1940–41

Sponsored for Science Teachers by
ILLINOIS STATE GEOLOGICAL SURVEY
URBANA

These geological field conferences, held in various parts of the State each year, are planned and conducted so as to supply to the science teachers in the schools of the State the information obtained by the Geological Survey in its researches on the geology, geologic history, physiography, and mineral resources of local areas throughout the State.

Saturday, September 28.....Oak Park Region
Features: Valparaiso and Tinley moraines of Wisconsin glaciation; abandoned glacial valley; shore features of glacial Lake Chicago; other physiographic phenomena; Niagaran limestone of Silurian system; quarries; rock and fossil collecting.

Saturday, October 5.....Rushville Region
Features: Several cyclothems and formations of Pennsylvanian system, unconformity between Pennsylvanian and Mississippian systems, and some Mississippian formations; Illinoian glacial drift and Peorian loess; terraces; fossil and rock collecting.

Saturday, October 12.....Metropolis Region
Features: Several formations of Eocene, Cretaceous, and Mississippian systems; valley-fill and terraces; development of Ohio Valley; fossil and rock collecting.

Saturday, April 26.....Waterloo Region
Features: Formations from Pennsylvanian down through Mississippian to Ordovician systems; visible structural relations; unconformities; sink-holes; fossil and mineral collecting.

Saturday, May 10.....Champaign Region
Features: Wisconsin glacial moraines and outwash; formations of Pennsylvanian system; sand and gravel pits and rock quarries; rock and fossil collecting.

Saturday, May 17.....Savanna Region (Palisades State Park)
Features: Maquoketa shale of Ordovician system and Alexandrian and Niagaran series of Silurian system; "Driftless Area"; development of Mississippi Valley and tributaries; valley-fills, loess-bluffs, and terraces; rock and fossil collecting.

All trips being promptly at 9:00 A.M. C. S. T. on the days scheduled. Groups assemble at high school buildings in towns named. No fees.

Participants will provide their own transportation and are requested to bring packed lunches.

EXPLORING THE FIELD OF PYTHAGOREAN NUMBER

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It has been the custom in some quarters to enter the territory of Pythagorean Number by way of the ponderous *pons asinorum*. It is probable however that Pythagoras, to whom is ascribed the discovery of the law of the hypotenuse, used a more inductive approach than Euclid, who lived a century or more later and gave the world the formulation known as Euclid Bk.I.47. Pythagoras and his followers undoubtedly discovered certain integer triads that satisfy the formula $h^2=a^2+b^2$. We can easily apprehend their accomplishment without crossing Euclid's "Bridge of the Asses" and with little difficulty extend the list of these triads far beyond the series bequeathed to us by the ancient Greeks.

The Pythagoreans are said to have been sadly puzzled by the hypotenuse number of the isosceles right triangle, or the square root of 2, and by other radicals that emerged from their experimentation. It is no wonder that such was the case, nor is it surprising that the tyro of today often stumbles over a new sort of number, so different in character from the familiar terms used in counting, that it has earned the term "irrational," or surd (ab ? surd) and is still called radical.

For the sake of high school students who are expected to tackle calculations with radicals their instruction in this subject should provide a well-paved approach to the comprehension of their nature and implications. Sophomores surely, and freshmen presumably, have been coached in the relative values of integers and in computing with positive and negative numbers as well. They probably comprehend both common and decimal fractions sufficiently well including mixed numbers and know something of recurring decimals. If they are not familiar with repetends, some practice with them will help to introduce the non-terminating decimals which are not repetitive as a first step toward appreciating the usefulness of approximation. Sooner or later they are to learn that physical measurements are relative and that practical accuracy is not perfect, but that it is a matter of degree, since evaluation of things lies somewhere between ascertainable upper and lower limits. All this

leads to the observation that grasp of radical values depends upon ability to calculate them and that the problem of finding the approximate square root of a given imperfect square should certainly be preceded by abundant practice in calculating square root in examples that come out even.

There is an inexhaustible supply of such material to be found in the number triads that have become known as Pythagorean numbers and in the so-called Pythagorean triangles—right triangles with integral sides. The simplest and best known example is the 3–4–5 triangle, which was familiar to the ancient Babylonians and was utilized by the Egyptians to enable them to construct square corners in their temple and pyramid building as well as in surveying plots of land.

There seems to be evidence that Pythagoras and his followers knew one endless chain of such triplets. We shall list them as Series I in our grouping because they are the simplest. The square of any odd number except 1 can be separated into two nearly equal integers. E.g., $3^2=9=4+5$, so 3, 4; 5 is the leader or initial triplet of this series. But $5^2=25=12+13$ and $7^2=49=24+25$ etc. The reader can extend this series in this manner without limitation.

If 9 is the first member of a Pythagorean triplet how shall 9^2 be decomposed into the other two members? What are the second and third members if 11 is the first? 13?

Putting this demonstration in a generalized algebraic basis, we may develop a formula to supply a succession of triplets in series thus:

Let h represent the hypotenuse number, b the base, and a the altitude number.

Then

$$(1)\quad h^2=a^2+b^2$$
$$(2)\quad h^2-b^2=a^2$$
$$(3)\quad (h-b)(h+b)=a^2$$

When (4) $h-b=1$, as is the case throughout this Series I,

Eq. (3) becomes (5) $h+b=a^2$

Subtracting (4) $h-b=1$

We have (6) $2b=a^2-1$

$$(7)\quad b=\frac{a^2-1}{2}$$

$$(8)\quad b=\tfrac{1}{2}(a+1)(a-1)$$

To evaluate Eq. (8) for b, substitute the odd numbers for a (excepting 1)

Example: Let $a=35$, then $b=\frac{1}{2}(36\times 34)=612$ and

$$h=612+1=613$$

Check: $612+613=1225=35^2$

Also:

$$35^2+612^2=613^2$$

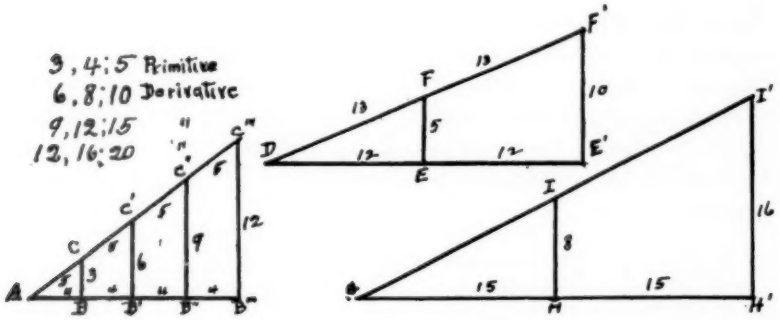
After the first three primitives in this (or any other series) are in hand the series may be readily extended by interpolation. Thus in Series I:

a	b	h
3,	4;	5
5,	12;	13
7,	24;	25
	etc.	

observe that a increases uniformly by 2 but b and h increase by the arithmetical progression: 8, 12, 16, 20, etc. indefinitely.

Derivative Triplets

We shall next distinguish *primitive* triplets from *derivatives*. It is clear in the accompanying cut that the triangles 6, 8; 10:



9, 12; 15; and 12, 16; 20: etc., are similar to the 3, 4; 5 triangle and are consequently equiangular with it. From this last more simple, unique, and elementary triplet the others are derived by multiplication. It is also apparent in the cut that 16, 30; 34 and 10, 24; 26 are *derivative* triplets. Derivatives, when integral, may be recognized as such by the presence of a common factor in their members. By canceling this factor out we reduce the triplet to its original or primitive form, just as we reduce a com-

mon fraction to its lowest terms. Find the primitive that is the original of:

21,	72;	75
36,	160;	164
60,	63;	87
24,	70;	74
100,	105;	145

The origin of derivatives is usually so patent as to render them inconsequential. We shall confine our attention to discovering primitives because all derivatives have their source therein. The members of such elementary triplets are always prime to each other (relatively prime). We shall find primitives in a satisfying abundance.

Extending the Researches of the Pythagoreans

Let us now turn our attention to the matter of developing other series of primitives that have not been bequeathed to us by the Greeks. We might generalize Equation (3) by letting $h-b=n$, whence we could develop the formula:

$$b=\frac{(a+n)(a-n)}{2n}.$$

From this formula it is possible to develop more triplets by substituting varying values for a and for n. Such an undertaking however would be a process of trial and error with consequent elimination of unsatisfactory results. It would produce so many derivative triads to be detected and rejected that we are constrained to set up a more exclusive method—one that engenders primitives only.

Initial Triplets, *Each being the Leader of a Series*

Series	$a=e$	$b=d$	h	$h-b$	Series	$a=e$	$b=d$	h	$h-b$	Series	$a=d$	$b=e$	h	$h-b$
II	8	15	17	2	X	204	253	325	72	IV	33	56	65	9
III	20	21	29	8	XII	252	275	373	98	VI	65	72	97	25
V	48	55	73	18	XIV	336	377	505	128	VIII	119	120	169	49
VII	88	105	137	32	XV	396	403	565	162	XI	207	224	305	81
IX	140	171	221	50	XVI	540	629	829	200	XIII	297	304	425	121

In the above list h denotes the hypotenuse number, b the

base, and a the altitude number of a Pythagorean triangle. Each of these sample primitive triplets is unique and underived. Each is also the first of an orderly group or series, unlimited in extent.

Characteristics

First: How many of the above triplets possess two even numbers? one? none? one odd number? two odd numbers?

Second: In how many is the hypotenuse number (h) an even number? an odd number?

Third: Is the altitude number (a) invariably even? If not, in which primitives is it odd?

Fourth: Does any member of the above number triplets possess a factor found in both of its other members? found in one of its other members?

Fifth: Find half of the sum of the odd numbers in each triplet. Is the square root of this half sum an integer in any case? in all cases?

Sixth: Find half of the difference of the odd numbers in each triplet. Is the square root of this half difference an integer in any case? in every case?

Generators

We should now be prepared to construct a method of reconstructing the primitives of the preceding table in case they become lost or forgotten and perhaps discover that such a method has general application. Out of the answers to the six questions of the preceding paragraph the following facts appear:

1. Each of the primitives tested is composed of one even number and two odd numbers.
2. The largest number (h) is always odd.
3. The smallest number (a) is even when $h-b$ is an even number. It is odd when $h-b$ is odd.
4. The members of each primitive have no factor common to all three and none common to two members.
5. Let e represent the even member in each primitive triplet and d represent the lesser odd number. Then in every case examined $\sqrt{\frac{1}{2}(h+d)}$ and $\sqrt{\frac{1}{2}(h-d)}$ are integers. These two integers will serve, if known, to restore any triplet lost or forgotten, as will presently appear. Let them be called the generators.

For convenience in handling such generators.

let

(1) $\sqrt{\frac{1}{2}(h+d)}=u$

and

(2) $\sqrt{\frac{1}{2}(h-d)}=v.$

Then

(3) $h+d=2u^2$

and

(4) $h-d=2v^2.$

By adding Eq. (3) and Eq. (4) we find that $2h=2u^2+2v^2$. By subtracting Eq. (4) from Eq. (3) we find that $2d=2u^2-2v^2$. Whence we have:

(5) $h=u^2+v^2$

and

(6) $d=u^2-v^2$

Now since the variable e represents the even number of a primitive,

(7) $h^2-d^2=e^2$

and

(8) $(h+d)(h-d)=e^2$

But the product of Eq. (3) and Eq. (4) is (9) $(h+d)(h-d)=4u^2v^2$ whence

(10) $e^2=4u^2v^2$

(11) $e=2uv$

Equations (5), (6), and (11) are the formulas by which we can generate a primitive. That they are universal in their application to primitive Pythagorean triplets and not restricted to the special examples of the preceding list is demonstrated in Arnold Dresden's "An Invitation to Mathematics" pp. 7–10. It should be noticed that $a=e$ and $b=d$ in some cases, but in others, $a=d$ and $b=e$. In other words the form of a primitive is sometimes (E) $2uv$, u^2-v^2; u^2+v^2 and sometimes (D) u^2-v^2, $2uv$; u^2+v^2, according to whether $a=e$ or $a=d$.

The Pairing of Generators

Possession of the formulas, however, does not complete our

preparation for applying them. We shall require assigned numerical values for u and v. Fortunately for us, after having come thus far, we learn that all integers are available to construct our primitives in series but that u and v must be paired according to certain laws or restrictions, due to the characteristic structure of primitives, viz:

1. u is greater than v
2. u and v must be relatively prime (prime to each other)
3. u and v must have different parity (both cannot be odd—or even.)

Beginning at the beginning, the most elementary pair is 2, 1; the next is 3, 2; the next is 4, 1. In obedience to the above laws:

When $u=2$, v must be 1.
When $u=3$, v must be 2.
When $u=4$, v may be 1 or 3 only.
When $u=5$, v may be 2 or 4 only.
When $u=6$, v may be 1 or 5 only.
Any even number may be u, when v is 1.
Any odd number may be u, when v is 2.

Proceeding thus we offer the following table which includes all pairs possible arrayed in order as far as space permits. This table may be expanded without limit.

TABLE OF PROPERLY PAIRED GENERATORS

Read down →	u, v	u, v	u, v	u, v	u, v	u, v	u, v	u, v	u, v	u, v	u, v	Series	Read horizontally
	2, 1	3, 2	4, 3	5, 4	6, 5	7, 6	8, 7	9, 8	10, 9	11, 10	etc.	I	
	4, 1	5, 2	×	7, 4	8, 5	×	10, 7	11, 8	×	13, 10	etc.	IV	
	6, 1	7, 2	8, 3	9, 4	×	11, 6	12, 7	13, 8	14, 9	×	etc.	VI	
	8, 1	9, 2	10, 3	11, 4	12, 5	13, 6	×	15, 8	16, 9	17, 10	etc.	VIII	
	10, 1	11, 2	×	13, 4	14, 5	×	16, 7	17, 8	×	19, 10	etc.	XI	
	12, 1	13, 2	14, 3	15, 4	16, 5	17, 6	18, 7	19, 8	20, 9	21, 10	etc.	XIII	
	14, 1	15, 2	16, 3	17, 4	18, 5	19, 6	20, 7	21, 8	22, 9	23, 10	etc.	XVI	
	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.		
Series	II	III	V	VII	IX	X	XII	XIV	XV				

The values of u and v for generating Series I are 2, 1; 3, 2; 4, 3 etc., as displayed on the first horizontal line of the table.

A START IN GENERATING SERIES I TO XII

Series I. $h-b=1$

u v	u^2-v^2	$2uv$	u^2+v^2
2, 1	3	4	5
3, 2	5	12	13
4, 3	7	24	25
5, 4	9	40	41
6, 5	11	60	61
	etc.		

Series II. $h-b=2$

u v	$2uv$	u^2-v^2	u^2+v^2
4, 1	8	15	17
6, 1	12	35	37
8, 1	16	63	65
10, 1	20	99	101
12, 1	24	143	145
	etc.		

Series III. $h-b=8$

u v	$2uv$	u^2-v^2	u^2+v^2
5, 2	20	21	29
7, 2	28	45	53
9, 2	36	77	85
11, 2	44	117	125
13, 2	52	165	173
	etc.		

Series IV. $h-b=9$

u v	u^2-v^2	$2uv$	u^2+v^2
7, 4	33	56	65
8, 5	39	80	89
10, 7	51	140	149
11, 8	57	176	185
	etc.		

Series V. $h-b=18$

u v	$2uv$	u^2-v^2	u^2+v^2
8, 3	48	55	73
10, 3	60	91	109
14, 3	84	187	205
16, 3	96	247	265
	etc.		

Series VI. $h-b=25$

u v	u^2-v^2	$2uv$	u^2+v^2
9, 4	65	72	97
11, 6	85	132	157
12, 7	95	168	193
13, 8	105	208	233
	etc.		

Series VII. $h-b=32$

u v	$2uv$	u^2-v^2	u^2+v^2
11, 4	88	105	137
13, 4	104	153	185
15, 4	120	209	241
17, 4	136	273	305
19, 4	152	425	437
	etc.		

Series VIII. $h-b=49$

u v	u^2-v^2	$2uv$	u^2+v^2
12, 5	119	120	169
13, 6	133	156	205
15, 8	161	240	289
16, 9	175	288	512
	etc.		

Series IX. $h-b=50$

u v	$2uv$	u^2-v^2	u^2+v^2
14, 5	140	171	221
16, 5	160	231	281
18, 5	180	299	349
22, 5	220	459	509
	etc.		

Series X. $h-b=72$

u v	$2uv$	u^2-v^2	u^2+v^2
17, 6	204	253	325
19, 6	228	325	397
	etc.		

Series XI. $h-b=81$

u v	$2uv$	u^2-v^2	u^2+v^2
16, 7	207	224	305
17, 8	225	272	353
	etc.		

Series XII. $h-b=98$

u v	$2uv$	u^2-v^2	u^2+v^2
18, 7	252	275	373
20, 7	280	351	449
	etc.		

The development of Series II employs the generators 4, 1; 6, 1; etc., reading down the first column.

For beginning the development of Series III read down the second column.

The development of Series IV requires 7, 4; 8, 5; 10, 7 etc., (the second line).

It should be noticed that when a is *odd* the succession is horizontal, otherwise it is down the column.

The zigzag line separates the generators that apply to series in which $a=d$ from those in which $a=e$.

The $\times$'s of the table indicate gaps caused by numbers occurring which have a common factor.

This table can grow indefinitely both horizontally and vertically.

This table may be expanded both horizontally and vertically to any desired limit.

The following integers are properly paired to serve as generators of primitive Pythagorean triplets. What triplets evolve from them?

(1) $u=38$, $v=15$. (2) $u=41$, $v=18$.

(3) $u=49$, $v=18$. (4) $u=75$, $v=22$.

Solutions:

(1)
$$2uv=2\times38\times15 \quad =1140=a$$
$$u^2-v^2=38^2-15^2=1444-225=1219=b$$
$$u^2+v^2=38^2+15^2=1444+225=1669=h$$

(2)
$$2uv=2\times41\times18 \quad =1476=b$$
$$u^2-v^2=41^2-18^2=1681-324=1357=a$$
$$u^2+v^2=41^2+18^2=1681+324=2005=h$$

(3)
$$2uv=2\times49\times18 \quad =1764=a$$
$$u^2-v^2=49^2-18^2=2401-324=2077=b$$
$$u^2+v^2=49^2+18^2=2401+324=2725=h$$

(4) The reader should be able to furnish the solution.

It was wrought not by kings or statesmen or even by dazzling intellectual geniuses, but by humble workers busied in homely toil, puzzling day after day over wheels and belts, and rollers and levers, and seeking some way to save time.—WILLIS MASON WEST in *Modern Progress*

A PHOTOELECTRIC SORTING AND COUNTING DEVICE

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This apparatus was built to demonstrate how photoelectric equipment can be used to count moving articles and to sort them according to color. It has been set up in a show window in a corridor of the Packard Laboratories of the Brookline High School for eighteen months and it still attracts many students daily. By snapping a switch next to the window the device is set in operation, a stream of black and white marbles issuing from an opening near the top, being counted as they move down a trough, the black marbles rolling straight down while the white ones are driven over into a parallel trough by the rapidly moving sorting hammer. With a blue filter in the light beam the device will reject black and red marbles while sorting white and blue ones.

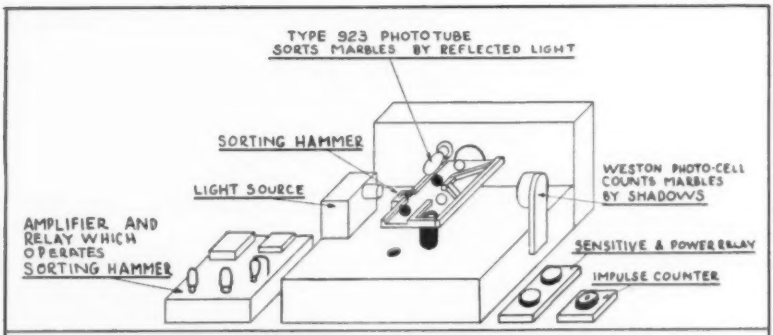

Fig. 1. PHOTOELECTRIC SORTER AND COUNTER

Figure 1 shows the general arrangement used while figure 2 gives details of the mechanism which keeps the marbles circulating. The elevating wheel is made of wood with a rim of sheet metal and with metal walls dividing the annular space between rim and wheel into pockets which hold one or two marbles each. When a pocket is at the bottom of the wheel the marbles rest on the metal rim which bends upward and holds them in place; while when a pocket is at the top of the wheel the floor slopes downward and the marbles roll out into the trough which carries them past the light beam. The motor is a "Gilbert Electric

Engine" which has a train of gears and which operates on 110 volts A.C.

The sorting hammer shown in figure 3 has worked perfectly

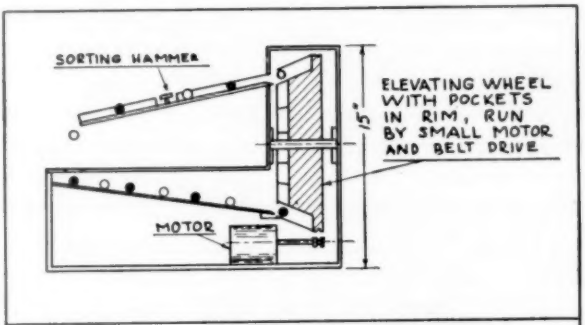

Fig 2 MARBLE ELEVATOR

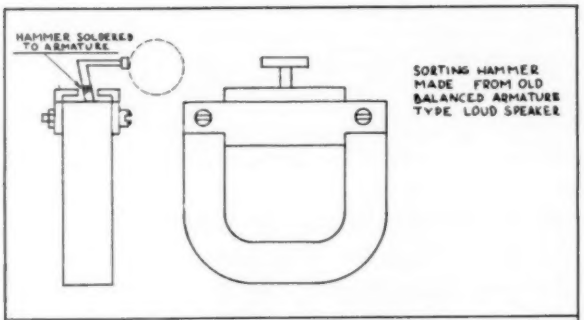

Fig.3 SORTING HAMMER

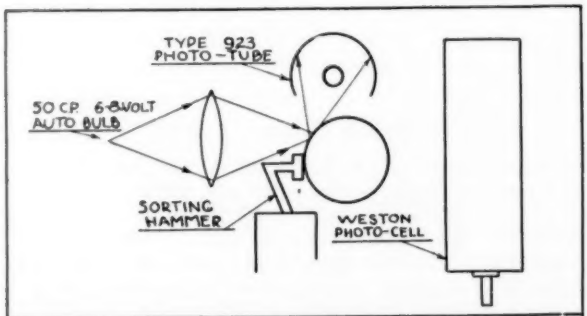

Fig.4. OPTICAL ARRANGEMENT

from the first and has ideal characteristics, striking very rapidly and forcefully and then immediately returning to its "rest" position. It will pick a white marble out from between two black ones when all three are moving rapidly down the trough, and the operation of the entire system is so rapid that the light beam must strike the marble when directly in front of the sorting hammer.

The amplifier circuit shown in figure 5 was developed especially for this device and has several advantages over simpler

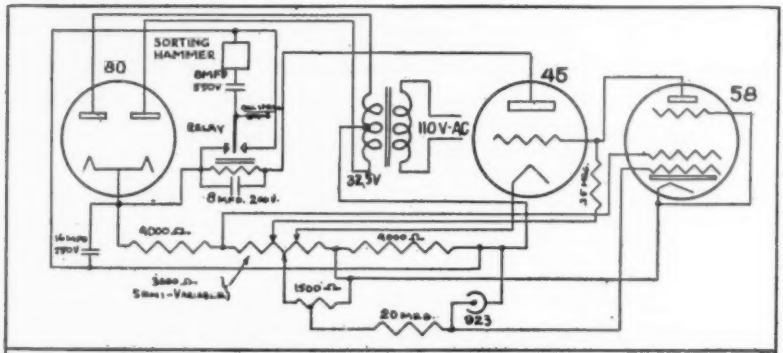

Fig. 5 AMPLIFIER FOR SORTER

circuits which nevertheless can be used with fairly satisfactory results. It should be noted that the sorting hammer derives much of its speed of operation from the fact that it is electrically driven both over and back again. When the relay is pulled down the hammer is driven over by a current which charges the 8-mfd condenser in series with the hammer and when the relay relaxes, this condenser discharges through the hammer and thus drives it back.

WHITE COLLAR JOBS

The secondary schools emphasize today, as they always have, preparation for occupations of the professional and clerical type—the so-called 'white-collar' jobs. The great majority of pupils in secondary schools are led by the studies which they pursue to hope for careers in 'white-collar' jobs. Any examination of the opportunities that are really open makes it clear that the hopes fostered by the present educational system are sure to be disappointed for most of those now registered in secondary schools.—*Excerpt from a report of the Committee on the Secondary School Curriculum of the American Youth Commission.*

THE TWO-YEAR PHYSICAL SCIENCE COURSE IN THE UNIVERSITY OF CHICAGO

SELBY M. SKINNER
The University of Chicago, Chicago, Illinois

Many universities, colleges and junior colleges have replaced their requirements of one or more courses in particular sciences by the requirements of a general course in the physical or biological sciences or both; sometimes this applies to all students and sometimes to the nonscience majors. Success, on the whole, has been comparable to results in the individual sciences, and in many cases there has been evident a distinct advantage in the quality and quantity of student learning. Similar courses have been attempted in the senior high school, and, in many cases do not seem to have fared so well. It is the purpose of this paper to discuss a course given in the two years preceding the freshman year in the university, which may be used to satisfy university graduation requirements, a course in the physical sciences designed to fulfill the needs of general education.

The general education movement developing in recent years has contained within it a recognition of the specialized nature of much which has been taught indiscriminately to students who planned to go into research, into the professions, into business, or just into employment of any kind they could obtain, many of them unable to continue throughout the whole four years of the university course, or perhaps even to reach the university. This recognition, while essentially correct, has led many to disparage specialized science under all circumstances; the manifest importance, and educational advantages inherent in scientific laws, generalizations, and interpretations, with their requirements of precise definition, logical thinking, and accurate working have at times been lost sight of. In fact, the word "specialist" has come to denote, in the thinking of many, a narrowness of thought and interest which is certainly not generally met among true specialists. On the other hand, the early influx into the curriculum of "Survey Courses" which were designed for the weaker students or taught by men competent only in one field, which required little thought, work, or understanding on the part of the student, and, in which at times, basically wrong "facts" were taught, has caused the survey course to acquire an undeserved disrepute, undeserved, that

is in the sense of latent possibilities. Fortunately, it is becoming more evident that courses covering several sciences in the same general grouping can be made useful from the point of view of general education, and yet retain the advantage of rigor, precision, and training in fundamental principles.

Such a course cannot be called a survey course, nor can it be called a specialized course. In its planning, it is necessary to choose from the sciences covered, those general laws and principles which have the greatest ramification throughout ordinary human experience and among the various sciences; these must be taught rigorously, and then applied to problems less important to the research man than to the individual student. The very process of choosing sifts out the factors valuable for general education, leaving behind those portions of the sciences which are so technical or required only for such specialized later work that they are of particular use only to the student majoring in the field.

Often it is not recognized that the great principles which form the framework of the various sciences are important because of the very generality of their application throughout major portions of the science and of other sciences. The Second Law of Thermodynamics is important because it ramifies throughout physics, chemistry, engineering, biology, certain phases of geology and metallurgy, etc. It is virtually impossible to find an experience or a natural process which would not involve some principle dependent upon the Second Law of Thermodynamics. Moreover, to draw the distinguishing line between the principle which is involved in experience and that operating in carefully prepared laboratory experiements is well-nigh impossible. The chief distinction of the laboratory experiment is the care which is taken to exclude extraneous factors beyond those under consideration. In analyzing experience, the scientist recognizes the mutual action of several factors. In problems of the classroom, more than one factor must at first be excluded, but as the analyzer continues to apply the principles he has learned, he can himself recognize the mutual action of several factors. The problem of planning a course in the physical sciences then becomes one of emphasis.

The nature of the world in which we live today requires the individual to be proficient in some one particular line, but also to have a good all-around background. The student should not be satisfied with a course in, say, physics alone, with no knowl-

edge of astronomy, chemistry, or geology; and no student has completed his general education without coming into contact with certain basic concepts and materials, or without developing appreciations and understandings, in the biological sciences, the humanities, and the social sciences.

The New Plan was introduced into the University of Chicago in 1931. A part of this reorganization has been the delimiting of the period up to the end of the sophomore year as that portion of the student's time within which he should complete his general education; from that time on his specialized courses should build upon the foundation laid by his general courses. Even before the New Plan there had been offered a lecture course called, "The Nature of the World and Man," which may lay claim to being one of the first general courses offered in the country. Under the New Plan, new courses were organized in the fields of the physical sciences, the biological sciences, the humanities, and the social sciences. Each student was required to pass a comprehensive examination covering his understanding of the basic concepts and principles in each of these fields, and to show satisfactory accomplishment in English. If he could do this without attending the courses, there would be no need for him to attend them; most students, however, found it necessary to attend, since there was no textbook in existence, nor had any student taken courses of this type and caliber previously. A reasonable amount of material chosen from the more important aspects of each science was to be mastered by the student, and this formed the framework of his understanding. Men renowned in their own fields took over the task of organizing the courses, and of choosing the essential material to be included in each one. This insured that there was no neglect of essential principles or facts, and that the material chosen was that most important both from the point of view of the student and from that of the science. The treatment was far from specialized, however; unique demonstration lectures, special textbooks (the New Plan series), new types of laboratory, and even new types of examinations have been developed or employed in the course.[1]

While the University continued to recognize the end of the sophomore year as a terminal point in general education, it soon came to be realized that there were some disadvantages

[1] For the history and details of the New Plan reorganization and courses, see "The Chicago Plan" by Chauncey Samuel Boucher, Chicago, University of Chicago Press, 1935

to a two-year program, which could be overcome for those students who would be under the university aegis for a longer period. In the early part of 1933, the faculty recommended that the two-year college consisting of the 13th and 14th years of instruction be extended by including the two previous years of the instruction of the students who were in schools on the campus. The Four-year College was the result. The faculty felt that by proper planning of courses, it should be possible to teach fundamental facts and principles rigorously even at the lower levels, and at the same time to provide the breadth essential to general education. With this in mind, in the year 1936–37, the two-year courses in the physical and biological sciences were established in the lower two years of the Four-year College. Students in these years were expected to choose one of the two-year courses, and passing such course, they would have passed the university requirements for the one-year course in that science, merely having to take the other science in the third year of the Four-year College. What the faculty faced then was this: to develop a course suitable for general education, yielding results of university caliber, and, which, because of the difference in age of the students was to be covered in two years. The courses which have been developed and are still in the process of developing, are known as Physical Sciences A & B, and Biological Science A & B.

Attention must particularly be called to the radical nature of allowing university credit for courses taken in the eleventh and twelfth years of instruction. The student passing through this program has definitely forged ahead of his fellows by an amount of time which may vary from two-thirds of a quarter to nearly two quarters. This is an important factor, when it is recalled that the average age at which a student passes into permanent employment in his chosen or ultimate field has advanced considerably within the last hundred years; sociologists view with alarm the results of postponing the assumption of responsibilities of the citizen, and of the years which must elapse before the student can marry and set up a home. For those students who wish to take advantage of the gain in time which results, not by graduating earlier, but by taking more electives, the added time provides a better background and well-rounded training. The gain in time, of course, results from eliminating the duplication of the usual high school course in chemistry or physics by the preliminary one in the university, and similar eliminations in other subjects.

According to the legislation, there was set up "a two-year course of four hours per week, with additional time, not to exceed two hours per week, for such laboratory as is regarded essential to effective instruction." The course has consistently been a six-hour course, two of the hours being used for laboratory projects. Whereas the one-year course on the 13th year level consists of over five hundred students in three lectures, together with smaller quiz sections, the two-year course consists of sections which are limited to thirty-five or fewer students. Their intelligence and ability is comparable, making allowance for age differences. At the end of each year there is administered a comprehensive examination, covering not only the material taken up from day to day, but measuring the extent of the student's assimilation and integration of this material. A good percentage of the questions on the comprehensive examination is common to the one-year and the two-year courses; due to the differences in emphasis, and to the division into two years, there is also a number of questions individual to each. Tests, similar to the comprehensives, and of different types as well, are given throughout the year, to let the student know how he is progressing, and to enable the teacher to send out quarterly advisory or progress reports to the parents; however, these tests do not determine his grade, nor enter into its determination. The grade is based upon the comprehensive. If the student transfers to another school, both advisory and comprehensive grades are sent with the transcript.

At first there was some question in the establishment of the one-year course as to the possibility of obtaining instructors adequately trained in four fields of specialization. Originally, there, the lectures in any one subject were given by a specialist who had attained a reputation in his subject. There was a marked advantage over the usual procedure of having introductory courses taught by graduate students whose chief attention was practically certain to be put on their own problems of obtaining a degree. The lecturer was genuinely interested in the development of this new type of course and brought to it a fund of knowledge and experience which was invaluable. Over the course of time, it was found that students and instructors in charge of quiz sections were able to obtain command of each of the subjects taken up in the course, so that they had actually mastered and gone beyond, the material included. In the two-year course, it was not possible to have separate instructors for the different portions of the material, partly because of the

age of the students and the unfortunate nature of any break in instructional methods, and partly because of the time that would be involved in relation to the smaller number of students. It has been found thoroughly satisfactory to have the course taught by men who have had intensive training in one of the fields and have supplemented this by basic training and interest in the other fields.

The content of the two-year course is drawn from the fields of physics, chemistry, geology, and astronomy, in the order of emphasis, with traces of material from meteorology, and other sciences. It is not desirable to present a chunk of material from one subject, and then lose complete sight of that subject forevermore, or anyway until the comprehensive examination. A certain amount of integration is essential, and certain material once taught needs to be brought out again later, in order to amplify it in terms of material which has succeeded it. On the other hand, if integration were carried so far that the basic content and characteristic processes of thought of each science disappeared in the mass of details, the course could hardly be said to develop scientific thought or attitude, and certainly would lose much of its right to be called science. Instances undoubtedly will be called to mind by everyone in which courses have been organized around situations in everyday life, arbitrarily chosen because of their supposed widespread application in the life of the individual, and which have turned into mere descriptive summaries, not worthy of being called science. Thus it is essential to decide what understanding must precede each particular topic, and whether these can be introduced at the time, or should have been treated earlier. And if early material is introduced merely because it is an aid to the understanding of the later topics, full advantage is not being taken of the time available, nor of the basic requirements of student interest. The placing of topics then, should be such as to make full use of material which has already been taught, and at the same time provide interest in and of itself.

The importance of student "interest," "purposes," and "needs" in choosing and organizing material presented to him, has been stressed by many.[2] As an aid to curriculum development these student attitudes lose much of their usefulness from

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[2] For example: Kilpatrick, W. H. *The Educational Frontier*, 1933, pp.(85) ff. Caswell and Campbell. *Curriculum Development*, American Book Co. 1935, pp. 415–426.

the fact that they are not measurable in any trustworthy sense.[3] In addition, they are transitory, and evanescent, and peculiar to the individual. Certainly, student interest must be considered. Future student needs also must be taken into account. The student, not having had full experience of the world into which he is progressing, does not develop those interests which will be of most use to him in later life except under experienced guidance. Certainly, the teacher who knows his subject and *how it applies in daily life and throughout the range of the sciences* is far more able to prepare a worthwhile course of study than is the student to whom everything is new. The good teacher is the one who can develop in his students enthusiasm for the subjects which will be most valuable to them. This does not mean that the curriculum must be hidebound and rigid; certainly provision must be made for differences in emphasis, and for extension into fields in which strong genuine interest develops—in particular, the teacher should be able to answer questions which are brought up by the students and which may be the beginning of a thread of continuing appreciation for the subject.

The order in which the topics are presented in the course under discussion is: Unit I. The Earth, Our Home. This includes discussions of the features of the earth, its shape, size, motions, constitution, and the effects of gravitation. Unit II. The Ever-changing Face of the Earth. This includes elementary weather elements, the processes of gradation, diastrophism, and volcanism. Unit III. Motion, includes a number of topics under kinematics, dynamics, and application to problems in experience. Unit IV. Energy, the Agent of all Change, including definitions and applications of work and energy, and energy transformations including those involving heat, ending with the principles as exemplified in machines. Unit V. The Molecular Nature of Matter, covering, liquids, solids, gasses, and solutions. Unit VI. Elementary Introduction to Chemical Change, and its three or four fundamental laws. Unit VII, Electrostatics and Electrodynamics. Unit VIII. Electricity and Matter, including those topics of modern and atomic physics which can be covered with the knowledge accumulated up to this time.

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[3] See, for example; Fitzpatrick, F.L. *Teachers College Record 38*, 1936–37, pp. 381–8. "In the absence of valid criteria concerning pupil interests, we may well proceed with intellectual caution, view our courses which are supposed to be based upon pupil interests with a modicum of suspicion, and abstain from proclaiming that such courses represent 'the way and the light'."

In the second year of the course there is: Unit I, The Chemical Reaction, including, combustion, oxidation and reduction, chemical activity and energy change, speed of chemical reaction, chemical equilibrium, and reactions that go to completion. Unit II. The Reactions of Ions in Solution, including conductivity and freezing point, Faraday's Law of Electrolysis, acids and bases, ionic double decompositions and equilibrium in such cases. Unit III. Atomic Structure and Chemical Behavior, including the periodic arrangement of the elements, the structure of the atom, electron configuration and chemical behavior, and general relationships in the periodic system. Unit IV. Metals and Non-metals, and their properties. Unit V. Carbon Compounds, including electron configurations as they affect the formation of carbon compounds, hydrocarbons, the architecture of organic compounds, oxidation and functional groups in organic compounds, carbohydrates, fats, and proteins. Unit VI. A rapid survey of Historical Geology, Unit VII, the Earth and its Neighbors, including the determination of position in the sky, time, the moon, the dynamics of the solar system. Unit VIII. Waves as carriers of energy, including data on waves in general, and particlar properties of different wave types, sound light, the electromagnetic spectrum, etc. Unit IX. Radiation and the Nature of the Stars, including the mapping of the stars, the spectroscope and the information it yields, and galaxies and supergalaxies.

Especially to be noticed is the fact that the first two units are descriptive and thereby furnish an easy transition from the student's previous nontechnical epperience. The problem of transition from the tenth year to the eleventh year has become important because of the change-over from courses which permit considerable memorization of content to one which begins to insist more and more upon thinking out of problems and relationships, and to put the responsibility for learning onto the student. Another step which has been taken to ease this transition is the administration of comprehensive type examinations to students at the end of the tenth year, only partially for purposes of grading, mainly for their experience in this type of examination.

Since no textbooks are available which will cover the needs of this type of course, the student is expected to obtain a rental set of books, chiefly those developed originally for the purposes

of the General Course in the Physical Sciences in the 13th year.[4] In addition the student is expected to purchase a syllabus for this particular course.[5]

In the second year, a breakage ticket is purchased to cover the cost of nonreturnable supplies and broken glassware. A sliderule is advised and instruction in its use is given, but it is not required.

Demonstration lectures provide the major source of student contact with the phenomena of the various sciences, since he has not time to develop large numbers of specialized techniques in the various subject fields. These are carefully planned, and the student is expected to know not only what was done, but why it was included as a demonstration experiment. Students are free to ask questions at any time during the lecture. Other periods include considerable class discussions, solving of problems, reports on various subjects assigned to or suggested by the student and supervised study.

Full use is made of the sound motion pictures developed by members of the faculty of the University of Chicago in collaboration with the Erpi laboratories and other sound and silent films. In using a sound film, it has been found valuable to present it once, then cover specific items in the film through lecture and discussion, and then, on another day to show the film again. It is important, of course, that the film be shown at the proper period within the progression of the instruction. If it be shown too soon, it is unintelligible, and if delayed, the impression made is slight—concepts will already have been formed, and points taken up which would otherwise be illuminated by the film will have been forgotten. An interesting point which we have noticed has been that these younger students do not receive the information from the sound film so rapidly as do the 13th year students: this is partially due to the vocabulary involved, but apparently also to a slower absorption of new experiences; because of it, we find that retention is better if the

[4] The New Plan textbooks used include: H. B. Lemon, *From Galileo to Cosmic Rays*, 1935; Croneis, Carey, and Krumbein, W. C., *Down to Earth*, 1936; Stephenson, R. J., *Exploring in Physics*, 1935; Bartky, A. W. *Highlights of Astronomy*, 1936, all by the U. of Chicago Press.

The following are also included in the rental sets: Schlesinger, H. I. *General Chemistry*. N. Y. Longman's Green & Co., 1937 (rev. ed.); Black, N. H. and Conant, J. B. *New Practical Chemistry*. N. Y. Macmillan, 1936; Holley, C. and Lohr, V. C. *Mastery Units in Physics*. Chicago. J. B. Lippincott Co. 1932.

[5] *Syllabus for Physical Science A*, 1938 and 1939; *Syllabus for Physical Science B* Univ. of Chicago Bookstore (mimeograph)

sound film is run at the low speed designed for silent films. Lantern slides are used in the material in geology and astronomy, where they are useful in supplementing the motion pictures.

The experimental period is devoted to the solving of problems by the student. At first the problems are suggested by the instructor, and are related to the content being covered at the time, but after a certain proficiency is attained in any particular subject, it is possible to give opportunity for the student to solve some problems of his choice. The experiments are presented as problems, and the student is expected to find a procedure for solving them, making use of his textbook, syllabus, various reference books available, and any other means he can find. Thus the stultifying effect of the cookbook type of laboratory procedure is avoided. For example, in chemistry, one of his early experiments is to determine which of two metals is the more active, with no apparatus available or permitted for measuring quantity of heat, or for weighing. Usually he has not realized the relation between activity and replacement reactions, and after considerable work, when he evolves a procedure, that relationship is not forgotten.

Field trips are taken to various points of scientific interest in the neighborhood, which include the Rosenwald Museum of Science and Industry, the Adler Planetarium, the Walker Geological Museum, and the Physics Demonstration Laboratory. The last one of these is particularly useful to the purposes of this course, and full advantage is taken of its proximity. The Physics Demonstration Laboratory was developed by Prof. H. B. Lemon in connection with the early years of the 13th year course. It consists of over two hundred permanently set up experiments, which have been chosen especially for their demonstration of fundamental principles, and the ease with which they bring out these principles. In contradistinction to many of the usual laboratory experiments, every effort has been taken to avoid the obscuration of the principle by the mathematics required to transform the data so that it covers the point at issue.

While originally devised as a substitute for laboratory work for the five hundred or more students taking the general course, who could certainly not be handled in traditional laboratories, particularly in the short portion of the year which can be devoted to physics instruction, the physics demonstration laboratory has, over the five or more years of its existence, developed

a number of interesting uses. It is now used to replace some of the experiments usually given to the students in the sophomore year or intermediate courses in physics, thus freeing time to be devoted to experiments not usually included. The permanent nature of the laboratory renders unnecessary the continual setting up of apparatus and its later disassembling, thus saving time, and concentrating the student's attention on the point being studied rather than on the details of apparatus setup. It is used for a teacher training course in physics in the summer session in which the teacher progresses at his own pace, and in which his particular needs and deficiencies can be met and attacked; credit for this course is applicable toward either education requirements, or physics requirements, and the teacher becomes sufficiently familiar with the apparatus and its gadgetry so that he can set up a similar laboratory altered to suit the needs of his own school. The laboratory is used to present basic experiments in the graduate theory courses, and for public open evenings, thus establishing a contact between the university and its alumni and that class of individuals always to be found in a university community who really wish to study some particular branch of science as a hobby.

Problems given students in the two-year physical sciences course include both the typical problems to be found in textbooks on the subject, and qualitative problems which test the student's ability to apply the principles he has learned, in simple situations. It is believed that while a sound understanding of basic principles is necessary, the student has not attained such an understanding without the ability to apply the principle. Problems such as the description of a particular type of landscape, the student to determine what geological agent was responsible for its formation, or the question as to why "weight" is essential for certain members of a football team, such as the guard, but less weight is considered better for the end, or the role of oxidation and reduction in the metallurgy of steel, force the student to apply the principles he has learned, and thereby increase his understanding of these principles.

The results which have attended the introduction of this course are gratifying. Student interest and student accomplishment are high. The former factor is difficult to measure except by the impression of the instructor; however, both total and percentage enrollment have increased each year for the four years since the course was introduced, which may be accepted

as some indication of student interest. Figures are available on the accomplishment. The Physical Science A and B classes[6] have consistently made a higher percentage of the total possible score, in their examinations than have the 13th year (college freshmen) students. However, more significant is a comparison between scores on the items in the 11th and 12th year comprehensive examinations which are common to the 13th year comprehensives. In every case since the introduction of the course (except the 12th year group in 1939) the 11th and 12th year groups have shown better accomplishment on common items. This superiority has varied from small amounts to those unquestionably statistically significant.[7] Evidently learning has been as great as that on the college freshman level, and therefore it is felt that the use of the course to satisfy college requirements is justified.

To sum up, then, it has been found possible to develop a course in the physical sciences on the 11th and 12th year levels, accomplishment in which is statistically comparable with accomplishment in a similar course in the 13th year, and to give credit for it toward satisfying university requirements. The course is not its final form, but is still in process of adaptation to those needs responsible for its introduction into the curriculum.

The author wishes to express his appreciation of the careful and important contributions to the development of this course made by his colleagues Theodore A. Ashford and Clifford Holley.

[6] Approximately half of the students involved in these examinations are a year younger than 11th or 12th year students would normally be. This is due not to "skipping" grades, but to the omission of one year in the grade school and high school in this institution. The extra year's instruction has been put back in the program and in another year or two, ages will be normal in the 11th and 12th year.

[7] (Up to more than 4σ.)

LIE DETECTOR HELPS DIAGNOSE MENTAL DISEASE

The lie detector (psychogalvanometer, in scientific terms) is proving a valuable aid in diagnosing mental disease and in helping the doctor find out whether the patient is covering up hallucinations or delusions, Dr. Paul Hoch, of the Manhattan State Hospital, reported this new use of the lie detector and at the same time warned criminologists to remember his findings in making their tests of criminal suspects.

If the suspect is suffering from mental disease or is a borderline case, Dr. Hoch explained, the lie detector responses will not conform to those normally expected.

Improvement in the mental condition of patients, whether spontaneous or due to treatment, also shows in the patient's response to the lie detector.

THE CONTENT OF JUNIOR HIGH SCHOOL SCIENCE*

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In planning and directing a program of science in the junior high school, the classroom teacher is confronted by the practical need for exact information concerning the material which should be included at the various levels and also the time allotment for the different topics. This information can be obtained in several ways. The very valuable interest studies provide information pertaining to the things which the children themselves wish to know. However, these alone may not include certain basic ideas which the pupils should begin to master at the level under consideration. Curriculum studies of needs of later years will give valuable assistance in adding such items. The existence of erroneous ideas and superstitions as disclosed by a number of studies over these areas provides still additional material to be inserted at some place in the course of study.

Careful analysis of the local environment, both in regard to the geography and the occupations of its citizenry, indicates the form of presentation and the desirable outcomes to be reached in the science course. There are other valuable sources of material written by experts that may be used, but unfortunately the busy classroom teacher may not have time to develop such a program even if the published studies were available to him, and usually they are not.

With the standard methods of curriculum construction cut off, the teacher may turn to existing courses of study, and having collected and compared a number of these, he may draft an outline to suit his particular needs. Now the big problem is solved. The teacher (or the committee of science teachers) has only the task of selecting a text or series of texts that will fit the course.

And what does he find here? Each of the publishers claims that his series is designed to fit existing courses of study, so this problem resolves itself into one of selecting the most attractive, best written, and most teachable text. But upon

* Paper presented before the General Science Section of the Central Association of Science and Mathematics Teachers at the annual meeting November 24, 1939. Composed of findings in the unpublished University of Iowa master's theses by E. P. VanderPloeg, C. Louis LeCocq, and O. F. Huffman, directed by the author.

making a careful examination it appears that the respective authors must have read and interpreted the various courses of study differently, for there is only partial agreement at the very best between the content proposed at each grade level in the several series.

The author discovered this many years ago, as did many of you, and finally he was forced to select the series of texts that most closely corresponded to his outline. This, I believe, is the common experience, and thus the course of study, regardless of how much effort was expended in its preparation, became that which the series of texts set up. This is a practical necessity, and I am not so sure that it is wholly bad. For as a rule these texts have been prepared after many years of study, and are based upon a course in operation, and therefore potentially teachable.

The writer became interested a few years ago in the problem of making some allowance at the senior high school level for the improved quality of pupils entering biology, chemistry and physics. This became increasingly important as these young sophisticates repeatedly announced, "Oh, yes, we had that in general science!" Recognizing the widespread influence of the text, a series of studies was undertaken at the University to determine:

(1) What agreement existed, if any, among the various authors as to what should be included in seventh, eighth, and ninth grade science?

(2) What topics were used in the development of common units?

(3) Were common concepts used in the development of the different topics?

(4) What concepts usually taught in the common high school subjects are being used at the various levels, and to what extent are they repeated in the three years?

(5) How much emphasis is given to the various commonly used concepts? Are they fully presented or just stated?

(6) To what degree are the several sciences used in presenting a given topic? Or are the topics separated as being physical, biological, chemical, astronomical, etc.?

Many other questions have arisen as these investigations advanced, and additional studies are now in progress with the hope that they may contribute to the solution of the problem of what shall be the content of the junior and senior high school science curricula. Of course, we realize that a program including such material is based upon published textbooks and existing courses of study; that completely new and widely differing courses may appear in the near future. It is the hope of the

National Science Committee that it may be able to supply materials for a more functional course, but great changes do not occur in a year, or two, or even ten, so we believe that we are obtaining a very good picture of the present course and an indication of possible future trends.

To make possible a more graphic presentation of at least a portion of our findings, a series of tables have been prepared which you will need to follow as I proceed with the explanation.

TABLE I. FREQUENCY OF OCCURRENCE OF COMMON UNITS IN THE SEVERAL SERIES

	7th Grade		8th Grade		9th Grade	
	5 Books Analyzed		4 Books Analyzed		4 Books Analyzed	
	Key Letter	Frequency	Key Letter	Frequency	Key Letter	Frequency
Fire, Heat, and Energy	E, O, W	5	E	2	A, L	2
Sources of Energy	X		T	2	H, N	2
					G	1
Machines			H	2	O	1
Light	F	1	F	2	M	2
Water	D, M, T	3	D	2	S	2
Rocks and Soil	I, V	4	J	2	CC	2
Air	C, N, U	4	C	1	T	3
Getting Acquainted with the Stars	H	1	O	3	V	3
Electricity and Magnetism	G, FF	2	G	2	K	3
Health and Physiology	L, Q, AA	3	R	2	W, Y	3
Food of Plants and Animals	K, HH, II	3	M	2		
What is Science and Method of Science	A, R, Z, BB	4				
Environment, Nature of, and Relationship of Living Things to—	B, J, S, Y, CC	3				
Control of Environment			A	1	E	2
Balance in Nature					GG	2
Weather and Climate			P	3		
Improving Living Things					AA	3
What is a Material	DD	1			J	1
Control of Living Things					BB	2
					Z	1
Trees	P	2				
Farm and Garden			Q	2		

Table I shows a list of units which occurred in the series of text books studied. The unit titles given are not necessarily in the words of the authors but have been revised to represent more truly the content covered in the unit. In several of the series a given unit is used in more than one level, although it does not necessarily follow that the title of the unit in Book II or Book III was the same as that in Book I. The content was

judged to be sufficiently similar to permit classification in this abbreviated table under the same heading. While the general content of a given unit was the same in all three books in one series, it is true that the emphasis was changed somewhat in each book. In some cases there was actual repetition of material.

This table should be read as follows: "Of the seventh grade books, five were analyzed; units dealing with fire, heat, and energy and the sources of energy were used in five books." The content overlapped so much that it was considered safe to list them together. As the texts were analyzed, each unit was given a key letter and after 26 units had been keyed, double letters were used. These key letters are of value in tracing the use of certain topics in the development of the units and following a given concept through the different units. "Units E, O, W, and X were used in all five seventh grade books. Units E, T, and H were used in two eighth grade texts. Units A, L, H, and N appeared in two ninth grade texts. Units G and O in one ninth grade text."

From this table it would appear that there is a uniformity of opinion as to what the content should be. However, there were 29 units used by the various authors in the respective seventh grade books that were not used in any other series. There were 14 such subject titles used in the eighth grade books and 21 in the ninth grade books. The titles have been omitted from the table but lists of them follow.

Seventh Grade Units Used in One Text Only

F	How We Use Light
H	Getting Acquainted With the Stars
DD	What Is a Material
EE	How Do Heating and Cooling Change Materials
GG	How Are Plants and Animals Alike
JJ	How Do Plants and Animals Live Together

Eighth Grade Units Used in One Text Only

A	Control and Improvement of Environment
B	Adaptations to Environment and Their Values
C	Proper Air Conditions as They Affect Comfort and Health
I	The Sun, Time and Seasons
L	Bacteria—Good and Bad
N	How the Community Protects Its Citizens' Health
S	How Plants and Animals Live in Different Zones

U What Man has Learned About the Story of Life
V Acids, Alkalies and Neutrals
W Sound
X Light

Ninth Grade Units Used in One Text Only

B The Work of the Factors of Our Environment
C Putting the Environment to Work
D How has Man Learned to Use the Materials of His Environment
F The Importance of Industry
G The Source of All Energy
H Heat Energy
I How Man has Gained Control Over the Energy Resources of the Earth
J What Things are Made of—Matter
L The Power to Do Things—Energy
N The Heat Using World
O Our Machine Age
P Development of Transportation
Q Development of Communication
R Sound
U The Storage and Use of Solar Energy by Living Things
X Conservation of Health, Wealth, and Safety
Z How We Control and Use the Microscopic World
DD Fields and Forests in the Service of Man
EE National Protection of Health
FF Our National Food Supply

The titles used by all the authors were widely different, which was to be expected. But the difference in actual content in the various units was unexpected. The content ranged from such units as "How Do Magnets Work" to as inclusive a unit a "Conservation of Health, Wealth, and Safety."

The general areas used in the various series at the different levels are limited to a comparatively small number. Fire, heat, and energy units appeared in 17 places in the text analyzed for all three levels. Light as an area was used in two out of four books in the eighth and ninth grades but was not considered to be so good at the seventh grade level. Water, rocks, and soil, astronomy, electricity and magnetism, health and physiology, and plants and animals were common to all levels. The air unit was used in four out of five seventh grade series and three out

TABLE II. TOPICS FREQUENTLY USED IN SEVENTH GRADE TEXTS

Descriptive Title	I	II	III	IV	V
Topics Appearing in Four Texts					
1. Occurrence and use of air	C	N	U	U	
2. Respiration and respiratory diseases	C	N	U	U	
3. Production and use of fire	E	O		O	O
4. Erosion and weathering	I	I	V	M	
5. Kinds of food	K		Y	K	II
6. Nature and composition of air	C	N	U	U	
7. Oxygen, oxidation and oxides		N	U	U	O
Topics Appearing in Three Texts					
1. The nature of matter	A		W		DD
2. Chemical change	A		W		W
3. The three states of water	D	M	T		
4. The water cycle	D	M	T		
5. The story of fossils	I	I		I	
6. How soil is formed	I		V	I	
7. The protective and reulative foods	K		Y		II
8. How our body is built up and maintained	L		Q		GG
9. Digestion of food	L			K	II
10. The effect of narcotics, nicotine, and harmful drugs on the human machine	L	Q		Q	
11. Our control of fire		O		O	O
Topics Appearing in Two Texts					
1. How a scientist attacks problems	A				BB
2. Factors of our environment and their effect on living things	A		S		
3. The nature of elements and compounds	A				W
4. Energy	A		X		
5. Living things adapt themselves to their environment	B		Y		
6. The air can exert pressure	C		U		
7. Measuring atmospheric pressure	C		U		
8. The composition of water	D		T		
9. How heat is transferred	E		I		
10. What can magnets do	G				FF
11. The compass	G				FF
12. How were rocks formed	I	I			
13. Kinds of soils and their value for growing things	I	I			
14. Different people should eat different kinds and amounts of food	K				II
15. Micro-organisms cause food to spoil	K			AA	
16. The skeleton and muscles	L	Q			
17. Teeth and their care	L			AA	
18. The circulatory system	L	Q			
19. The central nervous system—control centers of the human machine	L	Q			
20. Water is necessary for life		M	T		

TABLE II—*Continued*

Descriptive Title	I	II	III	IV	V
Topics Appearing in Two Texts					
21. Water as a worker		M		M	
22. Combustion and fuels		O			O
23. Parts and functions of a typical tree		P		P	
24. How we can protect trees		P		P	
25. Improvements of the soil			V	I	
26. Interdependence of living things			Y		JJ

of four ninth grade series, but in only one out of four eighth grade books. The reader may get additional information from this table as more time is taken to study it. The balance of the tables contain data for one grade only. Therefore, it must be compared with the corresponding column in Table I.

Table II consists of a list of topics used in the development of the various units in the several seventh grade texts. The Roman numerals at the headings of the columns are keys to the text in which the material is used. The list of texts with the key numbers may be found at the end of this paper. The capital letters in the columns are the same unit key letters appearing in Table I. From this table it is possible to see how the different authors used a common topic in developing a unit and also how the topics were used in developing different units. For example, Topic I, "Occurrence and Use of Air" was used in four texts to develop three different units—C, N, and U. It will be unnecessary for me to follow through each of the topics listed in this table. You will no doubt be interested in tracing the different commonly used topics and in observing the variety of ways in which they have been used. By referring to Table I you can discover, at least within the more widely included areas, what the general nature of the different units were in which a given topic was used. Only those topics were included that were common to at least two units. A long list of topics was found common to one text only.

Table III shows the concepts used, the fields from which they were chosen, and the relative emphasis placed upon them by the different authors. The check lists were obtained from analyses of the concepts usually included in the senior high school courses in the various subjects with the exception of astronomy. The astronomy list was developed from the text analyzed by simply adding new concepts to the list as they appeared in reading.

TABLE III. TOTAL CONCEPTS. NUMBER PRESENT IN EACH SEVENTH GRADE TEXT AND PER CENT OF TOTAL IN EACH TEXT

	Totals in Check Lists	Text I	Text II	Text III	Text IV	Text V
Astronomy	33	21 64%	4 12%	6 18%	0 0%	9 27%
Biology	587	102 17%	113 19%	102 17%	93 16%	100 17%
Chemistry	349	24 7%	49 14%	56 16%	39 11%	49 14%
Geology	132	20 15%	39 30%	14 11%	27 20%	3 2%
Health	350	65 19%	29 8%	25 7%	29 8%	12 3%
Physics	261	49 18%	8 3%	56 21%	13 5%	45 17%
TOTALS	1712	283 16.5%	243 14.2%	259 15.1%	201 11.7%	218 12.7%

Our check list of biology concepts contained a total of 520 items. However, you will note that in Table III there are 587. This means that 67 more biology concepts were found in the seventh grade books than are usually included in the course in high school biology. We note that Text I uses 102 biology concepts or 17% of the material usually taught in tenth grade biology. The other texts used respectively 19, 17, 16, and 17 per cent. This would seem to indicate a fairly uniform agreement as to how much of the seventh grade material should be devoted to biological topics. However, examination of the particular concepts used shows that a great many of the concepts in the text using only 93 were not included among those concepts in the text using the maximum number 113.

There is a rather close agreement as to the total number of concepts regardless of area which should be included in a seventh grade science book. The number of concepts used in the five series investigated ranged from 201 to 283. While the percentages have not been worked out in this table, it would be comparatively simple to determine the proportion of the content which should be devoted to each of the separate sections,

as suggested by these authorities. That is, the authors of Text I used 102 biology concepts out of a total of 283 concepts of all sciences. They felt that 36% of the seventh grade material should be biological.

TABLE IV. LIST OF BASIC CONCEPTS OF EACH SCIENCE INCLUDED IN THE MAJORITY OF 7TH GRADE TEXTS ANALYZED

The complete list of concepts used in the several texts is too long to permit publication in periodical literature. However, the following is a list of those concepts appearing in three or more tests.

Astronomy

Concepts appearing in three texts:

1. The earth rotates on its axis once in every 24 hours giving us night and day.

Biology

Concepts appearing in five texts:

1. Digestion makes food soluble and changes it chemically permitting assimilation.
2. Respiration is the process by which a cell in the body takes in oxygen and gives off carbon dioxide and water.
3. Red corpuscles carry food and wastes to and from cells.
4. Water constitutes about 60% of all animal tissue.
5. Water is necessary as a food.
6. Vitamins A, B, C, D, E, and G, and why they are necessary.

Concepts appearing in four texts:

1. Both plants and animals breathe.
2. The control of insects depends largely on the birds, so if we kill the birds the insects will get out of control.
3. Roots carry the minerals dissolved in water from the earth to the leaves.
4. Fungi are spore plants which have no chlorophyll and have to depend upon other plants or animals for organic food.
5. Bacteria of decay are most valuable to man.
6. Nitrifying bacteria change nitrogen into a soluble form so that it is available to plants.
7. Loam is fine sand which is mixed with a large quantity of decayed organic matter known as humus.
8. Soil is cultivated to keep it loose for the roots to penetrate, to conserve moisture, and to kill weeds.
9. In the mouth the food is crushed and mixed with saliva.
10. The general purpose of digestion is to put foods in a soluble form so that they may pass through the walls of the intestines.
11. Respiration supplies the energy for various life processes.
12. Perspiration leaves the body through 2,000,000 sweat glands and the evaporation of the perspiration regulates the body temperature.
13. Proteins contain nitrogen and are essential in the production of living tissue.
14. Fats are the chief energy producers.
15. In order to maintain a proper food ratio we must have a mixed diet.

Concepts appearing in three texts:

1. Plants and animals are called organisms.

2. The fish breathes through the mouth and gill slits and takes oxygen directly from the water by osmosis.
3. Many insects lay their eggs in the water and their young live either in the mud or in the water.
4. Air pores of a leaf are called stomata.
5. Transpiration is the process of excretion of water from plants in the form of water vapor escaping through the stomata.
6. Roots take in water and food and also hold the plant in position.
7. The stem is the path by which food is taken from the roots to the leaf and by which manufactured food is carried from the leaf to be stored in the roots.
8. Molds are a kind of fungus as are mushrooms, rusts, toadstools, puff balls and mildews.
9. Bacteria which live in the roots of legumes change nitrogen of the air to food for plants.
10. In favorable conditions yeast plants cause the process known as fermentation.
11. Gravel is composed of small, usually round stones.
12. Clay is very fine, hard-packed soil which retains water well, if allowed to soak in.
13. Fertilizers are substances used to replace elements taken from the soil by plants and all other elements.
14. A plant grows by increasing the number of cells which compose it.
15. Bone is composed of phosphate and carbonate of calcium.
16. The normal temperature of the body is 98.6° and is always this in healthy people.
17. Drinking of water is necessary for proper excretion of wastes from the body.
18. Mineral salts are necessary in the formation of bone, teeth, blood, and digestive fluids.
19. Vitamins are necessary for growth and normal health.
20. Foods are preserved by cold storage as bacteria do not thrive in the cold.
21. Plants manufacture starches and sugar compounds out of carbon dioxide and water using the energy of the sun.

Chemistry

Concepts appearing in five texts:

1. Solid state of matter.
2. Liquid state of matter.
3. Gaseous state of matter.
4. Oxidation.
5. Kindling temperature.

Concepts appearing in four texts:

1. Boiling point.
2. Freezing point.
3. Water vapor.
4. Solution.
5. Contrast of elements and compounds.
6. Percentage of oxygen and nitrogen in air by volume.
7. Oxidation and combustion.
8. Fire extinguisher.

Concepts appearing in three texts:

1. Purification of water by boiling.
2. Purification of water by distillation.
3. Electrolysis of water.
4. Chemical change: decomposition.
5. Combustion as a chemical change.

6. Carbon dioxide cycle.
7. Preparation of oxygen.
8. Hydrogen: burns in air.
9. Commercial preparation of charcoal.
10. Action of air on common metals.
11. Protective coating to prevent corrosion.

Geology

Concepts appearing in five texts:

1. Erosion.

Concepts appearing in four texts:

1. Weathering.
2. Caverns: Work of water under ground.
3. Glaciers: Work of ice.
4. Granite: Igneous—formed by vulcanism.
5. Sandstone: Sedimentary—by running water.
6. Limestone: Sedimentary—by running water.

Concepts appearing in three texts:

1. Vulcanism.
2. Springs: Work of ground water.
3. Igneous: Formed by vulcanism.
4. Metamorphic: By diastrophism.
5. Marble: By diastrophism.
6. Sedimentary: By running water.
7. Shale: By running water.
8. Quartz: Minerals—by ground water.
9. Feldspar: Minerals—by ground water.
10. Mica: Minerals—by ground water.
11. Fossils.
12. Delta.

Health

Concepts appearing in three texts:

1. Value of milk in the diet.
2. Amount of milk to use per day.
3. Cleanliness and care of the skin.
4. Dust, germs, and moisture in the air.
5. Alcohol is a habit forming drug.
6. Burns and scalds.
7. Fires, loss.
8. How to put out fires.
9. Physiology of the digestive system.
10. Physiology of breathing.

Physics

Concepts appearing in five texts:

1. Weight of air.
2. Height of atmosphere.

Concepts appearing in four texts:

1. Convection.

Concepts appearing in three texts:

1. Matter.
2. Molecule.
3. Atom.
4. Air Pressure.
5. Heat and temperature.
6. Centrigrade.
7. Fahrenheit.
8. Evidence of Expansion.
9. Calories.
10. Humidity.

Analysis of Findings for the Seventh Grade

The conclusions drawn from the seventh grade are as follows:

No complete units were found to be common to the five texts analyzed. Two units were common to three texts, five units appeared in two texts, and twenty-nine units appeared in only one text.

Of the total of one hundred fifty-five topics appearing in the five texts, only 11% were used in the majority of the texts. No topic appeared in all five of the texts. Seven topics appeared in four texts, ten topics appeared in two texts. Seventy and nine-tenths per cent of the topics were used in only one text.

Of the total of six hundred fifty concepts appearing in all the texts only eighty-six of 13.2% were found to be common to three or more texts.

On the basis of the above conclusions we can say that there is a distinct lack of uniformity in the choice of units, topics used under the units, and in concepts used in the development of the topics, in seventh grade science books of series of texts for junior high school science. Therefore, the teacher is justified in organizing the seventh grade course to suit local and pupil needs.

Of the total five hundred eighty-seven biology concepts included in the check list three texts used 17%, one used 19%, and one used 16%. In astronomy the range was much greater with text I including 64% of the concepts and text IV using no astronomical concepts. In chemistry 16% was the maximum amount used and 7% the minimum. A much greater range was found in geology where the maximum amount of the concepts used in any text was 30% with 2% as the minimum. In health the amount ranged from 19% to 3%, and in physics the maximum was 21% with a minimum of 3%.

The percentage of the total number of concepts in the check lists appearing in the seventh grade texts examined gives us some idea of the background for the science taught in the upper levels. In Table III we find the percentages 16.5, 14.2, 15.1, 11.7, and 12.7, respectively for texts I, II, III, IV, and V. These values are not to be interpreted as the amount of space devoted to science in the various texts but rather as the number of concepts presented by each seventh grade science text.

(*To be concluded in November*)

AN ELECTRICAL SELF-TESTER FOR CHEMISTRY STUDENTS

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The idea of designing a chemical self-tester was suggested by the following item, which appeared in the *Science News Letter* for February 18, 1939: "The quiz idea has been applied to museum exhibits: the visitor chooses to press one of five labeled buttons beneath each mineral exhibit, and his score is automatically registered on a dial, together with the right answers, when he finishes the test." It was suggested to a project committee in a chemistry section that they study the possibilities of adapting some features of the above quiz idea to certain phases of work they had been doing.

TABLE 1

	TEST CARDS	RESPONSE CARDS				
		A	B	C	D	
Plug 1 o	chlorate	ClO_2	ClO_3	Cl	ClO_4	
2 o	sulfite	SO_2	SO_4	SO_3	SO	
3 o	bromide	Br	BrO_3	BO_3	B_4O_7	
4 o	acetate	$C_4H_4O_6$	C_2O_4	Cr_2O_7	$C_2H_3O_2$	Plugs A
5 o	bisulfite	CNS	HSO_4	HSO_3	S_2O_3	B
6 o	sulfide	SO_3	S	SO_4	SO_2	C
7 o	tetraborate	BrO_3	BrO_4	B_4O_7	BO_3	D
8 o	hypochlorite	ClO_2	ClO	ClO_3	ClO_4	
9 o	dichromate	Cr_2O_7	ClO_4	C_2O_4	CrO_4	
10 o	nitrite	NO_3	NO_2	NO	N	

The committee drew up tentative plans for carrying out the project, and delegated the more or less specialized tasks involved to individuals best qualified to perform them. Several boys with a background of shop training were assigned the job of constructing the testing board; the electrical wiring required the services of two boys whose special field of interest was electricity; the job of lettering the several hundred 3×5 testing cards was delegated to a number of pupils familiar with lettering techniques. The division of labor reduced the time required to complete the project.

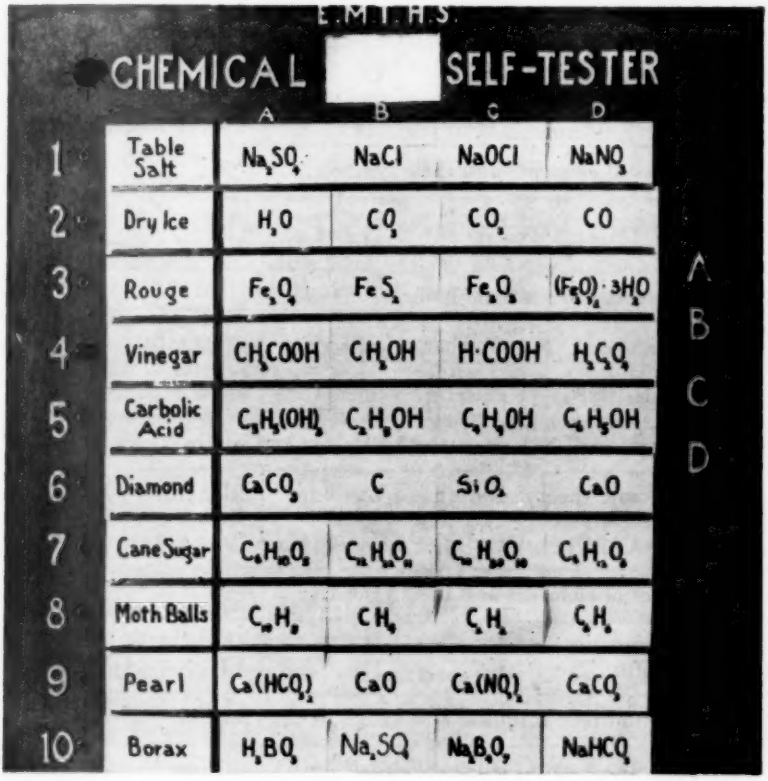
The original plans drawn up by the electrical committee were unnecessarily elaborate, and called for complicated wiring systems. These were considerably simplified as the work progressed—other short-cuts and novel innovations naturally suggesting themselves when the work had advanced too far to permit their incorporation. The completed tester, therefore, while very satisfactory in performance, is not precisely a model of simplicity so far as electrical hook-up is concerned.

Stated as briefly as possible, the modus operandi of the Self-Tester is as follows:

On a ply-wood board (36″×36″) fifty printed cards are arranged as indicated in Table 1.

In this particular illustration we are testing ability to associate terms with symbols, using the "multiple-response" recognition test form. Ten "test-cards" are arranged vertically at the left of the board, and each one of the terms has four "response-cards" arranged in horizontal rows to the right. The operator makes an electrical connection for the horizontal row by plugging in on No. 1 at the left, and then selects what he believes to be the correct response by plugging in on one of the four plugs located on the right-hand side of the board. If he plugs in on the correct response, B in this case, a light in the window on the upper part of the board flashes on; if he plugs in on the wrong response, a gong sounds. The operator of the Self-Tester next plugs in on No. 2, and again selects one of the four responses by plugging in on A, B, C, or D. He continues in the manner indicated until he has gone down through No. 10. Every time he succeeds in flashing on the light and, of course, in avoiding the gong, he credits himself with ten points. A multiple-switch, located in the top left-hand corner of the board, regulates the "shuffling" of the response cards, and helps to disconcert the operator who attempts to memorize the correct answers by location.

The possibilities of the tester are limited only by the number and variety of test and response cards one cares to prepare. In the photograph the cards have been arranged to test the operator's ability to associate common names with formulas; other possibilities are illustrated in the following table (Table No. 2):


E.M.T.H.S.
CHEMICAL SELF-TESTER
A B C D
1 Table Salt Na_2SO_4 NaCl NaOCl $NaNO_3$
2 Dry Ice H_2O CO_2 CO_2 CO
3 Rouge Fe_2O_3 FeS_2 Fe_2O_3 $(Fe_2O)_2 \cdot 3H_2O$
4 Vinegar CH_3COOH CH_3OH $H \cdot COOH$ $H_2C_2O_4$
5 Carbolic Acid $C_3H_5(OH)_3$ C_2H_5OH C_6H_5OH C_6H_5OH
6 Diamond $CaCO_3$ C SiO_2 CaO
7 Cane Sugar $C_6H_{10}O_5$ $C_{12}H_{22}O_{11}$ $C_{60}H_{20}O_{60}$ $C_6H_{12}O_6$
8 Moth Balls $C_{10}H_8$ CH_4 C_2H_2 C_6H_6
9 Pearl $Ca(HCO_3)_2$ CaO $Ca(NO_3)_2$ $CaCO_3$
10 Borax H_3BO_3 Na_2SO_4 $Na_2B_4O_7$ $NaHCO_3$

Photograph of Testing Board with cards arranged to test operator's ability to associate common names with formulas.

TABLE II

TEST CARDS	RESPONSE CARDS			
	A	B	C	D
I. Names of radicals and their symbols:				
1. Chlorate	ClO_4	ClO_3	ClO_2	ClO
2. Acetate	C_2O_4	$C_4H_4O_6$	Cr_2O_7	$C_2H_3O_2$

TABLE II—*Continued*

TEST CARDS	RESPONSE CARDS			
II. Common names and their formulas:				
1. Epsom salt	Na_2SO_4	$KNaC_4H_4O_6$	$MgSO_4$	KNO_3
2. Muriatic acid	H_2S	H_2SO_3	HCl	HNO_3
III. Chemical terms and their formulas:				
1. Ferrous sulfate	$FeSO_4$	FeS	$Fe_2(SO_4)_3$	$FeSO_3$
2. Mercuric chloride	$MgCl_2$	HgCl	$Mg(ClO_3)_2$	$HgCl_2$
IV. Names of elements and their symbols:				
1. Silicon	S	Si	Sn	Sc
2. Magnesium	Mg	Mn	Mo	Hg
V. Formulas and common names:				
1. $NaNO_3$	Glauber's salt	sal soda	Chile saltpeter	table salt
2. $C_3H_5(OH)_3$	glycerin	phenol	alcohol	ethanol
VI. Important discoveries or contributions and names:				
1. Atomic theory	Dalton	Lavoisier	Richards	Berzelius
2. Electrolysis of Al_2O_3	Priestley	Urey	Hall	Cavendish
VII. Names of elements and their valences:				
1. Aluminum	I	II	III	IV
2. Sulfur	I	III	VI	V
VIII. Acid and base formulas and names of salts formed:				
1. $H_2SO_4 + Ca(OH)_2$	calcium sulfite	calcium sulfate	calcium sulfide	calcium bisulfite
2. $Fe(OH)_2 + H_2S$	ferric sulfide	ferrous sulfate	ferric sulfite	ferrous sulfide
IX. Names of elements and families to which they belong:				
1. Nitrogen	halogen	calcium	phosphorus	sodium
2. Radium	zinc	iron	calcium	copper
X. Atomic Weights, sp. gr., important temperatures, etc.:				
1. Sulfur	16	32	8	24
2. Sulfuric acid	.89	1.83	1.2	1.5
3. Absolute zero	0°C.	−273°C.	373°A	212°F.
4. etc.	0°C.	−273°C.		

A READING LIST FOR BIOLOGY

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This article is concerned, primarily, with the question of selection of books in the field of biological science. Books for biology reading may be roughly classed into two groups: First, those books of a clearly reference type and second, those books relating to biology or natural history which, because of their interest factor, will be read by pupils of their own accord if given encouragement to do so. Books of the first type should not be chosen unless there is a reasonably clear and preconceived plan as to how they are to be used. The second class may be selected upon the basis of a belief, from past experience, that these books are of such a nature that they will prove interesting and *will be read* by the students. The teacher or committee selecting books of this group should, if possible, examine them before a final decision to purchase. In addition, it is desirable to go through the cards of books already in the library noting how frequently they have been "charged out" and thus checking the reliability of past judgments.

The following is a reading list of books compiled in the belief that it contains many of the recent and a few of the older books that are definitely readable and interesting to high school students of the second-year level. The writer recently went through the cards of all books in the list and, with few exceptions, no book is included which has been "charged out" fewer than three times per year for each year it has been in the library. Some of the books have been unusually popular. For example, "Bring 'Em Back Alive" has been "charged out" one hundred forty-three times. Needless to say, the book has had to be rebound.

The following reading list has been found to be quite useful to the students of our school. It must not be assumed that this list contains all titles that would be valuable for the purposes suggested above. It is merely a list of books known to be interesting to high school biology students. Titles prefixed with an (*) are more than usually popular, those with (**) most popular, those with an (x) have excellent illustrations, those with an (e) are somewhat too easy for second year pupils, while those with an (s) are somewhat too difficult or serious.

** Akeley, Delia S. *J. T. Jr.; the Biography of an African Monkey*, The Macmillan Co., N. Y. 1929.

Akeley, Mary L. *Carl Akeley's Africa*, Dodd, Mead & Co., N. Y. 1929.
x Aymar, Gordon C. *Bird Flight*, Dodd, Mead & Co., N. Y. 1936.
Beamish, Huldine V. *Your Puppy and How to Train Him*, L. Furman, N. Y. 1938.
e Beebe, C. W. *Exploring with Beebe*, Putnam's Sons, N. Y. 1932.
Beebe, C. W. *Arcturus Adventure*, Putnam's Sons, N. Y. 1926.
Beebe, C. W. *Nonesuch: Land of Water*, Blue Ribbon Books, N. Y. 1932.
* Beebe, C. W. *Half Mile Down*, Harcourt, Brace & Co., N. Y. 1935.
Beebe, C. W. *Zaca Venture*, Harcourt, Brace & Co., N. Y. 1938.
Beebe, C. W. *Beneath Tropic Seas*, Blue Ribbons Books, N. Y. 1928.
Benz, Francis E. *Pasteur, Knight of the Laboratory*, Dodd, Mead & Co., N. Y. 1938.
Bostock, Frank C. *The Training of Wild Animals*, Century Co., N. Y. 1903.
** Buck, Frank. *Bring 'Em Back Alive*, Garden City Publishing Co., N. Y. 1935.
** Buck, Frank. *On Jungle Trails*, World Book Co., Yonkers-on-Hudson, N. Y. 1936.
** Buck, Frank. *Wild Cargo*, Simon-Schuster, N. Y. 1932.
** Buck, Frank. *Fang and Claw*, Simon-Schuster, N. Y. 1935.
x Butler, Ovid M. *American Conservation*, American Forestry Association, Washington, D. C. 1935.
Buytendijk, F. J. J. *The Mind of a Dog*, Houghton Mifflin Co., Boston. 1936.
s Carrel, Alexis. *Man, The Unknown*, Harper & Bros., N. Y. 1935.
*x Chapman, Wendell & Chapman, Lucy. *Wilderness Wanderers*, Chas. Scribner's Sons, N. Y. 1937.
s Chase, Stuart. *Rich Land Poor Land*, McGraw-Hill & Co., N. Y. 1936.
x Church, Albert C. *Whale Ships and Whaling*, W. W. Norton & Co., N. Y. 1938.
Clarke, F. E. *Cats and Cats*, The Macmillan Co., N. Y. 1937.
s Clute, W. N. *The Common Names of Plants and Their Meanings*, W. N. Clute, Indianapolis. 1932.
Cole, Fay Cooper. *The Long Road from Savagery to Civilization*, Williams-Wilkins, Baltimore. 1933.
Comstock, Anna B. *The Pet Book*, Comstock Publishing Co., Ithaca, N. Y. 1930.
Cooper, Courtney R. *Lions 'N Tigers 'N Everything*, Little, Brown & Co., Boston. 1936.
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The following 1939 books have been examined and seem to qualify for our list. They will be on our requisition for purchase for the new semester. Time will tell whether they fulfill our expectations of them.

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Peattie, Donald C. *Flowering Earth*, Putnam, N. Y.
Pickwell, Gayle Benj. *Birds*, McGraw-Hill & Co., N. Y.
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Selingman, Herbert J. *Race Against Man*, Putnam's Sons, N. Y.
Snedigar, Robert, *Our Small Native Animals, Their Habits and Care*, Randon House Inc., N. Y.
Williams, Henry Smith. *The Private Life of Birds*, Robert M. McBride, N. Y.

COMPENDIUM OF MATHEMATICAL APPLICATIONS

The Seventeenth Yearbook of The National Council of Teachers of Mathematics will be entitled "Compendium of Mathematical Applications." It is contemplated that the principal topics of Arithmetic, Algebra, Geometry and Trigonometry will be listed alphabetically, together with practical applications in some of the fields and vocations where the particular topic is useful. Since the book is being prepared as an aid for the teacher of elementary mathematics, problems will be of a type and at a level to appeal to the high school student. A cross-index will enable the teacher to survey the breadth of application in any particular field.

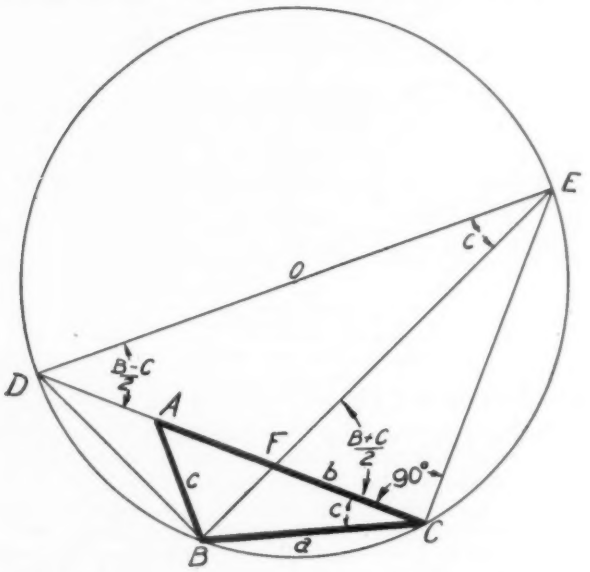
The following committee has been appointed to prepare the Yearbook: L. E. Boyer, State Teachers College, Millersville, Pa.; Ruth O. Lane, University High School, Iowa City, Iowa; Nathan Lazar, Bronx High School of Science, New York, N. Y.; F. L. Wren, George Peabody College for Teachers, Nashville, Tenn.; Edwin G. Olds, Carnegie Institute of Technology, Pittsburgh, Pa., Chairman. However, no small committee could hope to have the breadth of education necessary to survey all fields and the above committee is no exception. Therefore, it earnestly solicits the aid of all friends of mathematics in discovering the most significant applications of elementary mathematics. Contributions and suggestions should be submitted to a member of the committee as soon as possible.

THE LAW OF TANGENTS

JOHN J. CORLISS
DePaul University, Chicago
JOSEPH J. URBANCEK
Chicago Teachers College

Various methods for proving the Law of Tangents in Trigonometry may be found in books on the subject. The method presented here involves a simple geometric proof. Investigation in available literature leads the writers to believe that this method offers a contribution to the subject, since no similar method was found.

Given any triangle ABC with $AB=c$, $BC=a$, $AC=b$.



1. Extend CA to D, making $AD=AB=c$, whence $\angle ADB = \angle ABD = A/2$, A being an exterior angle of triangle ABD.
2. Lay off $AF=AB=c$, and construct BF, whence $\angle ABF = \angle AFB = 90°-A/2$, since triangle ABF is isosceles.
3. $\angle DBE = \angle DBA + \angle ABF = A/2 + 90° - A/2 = 90°$.
4. Construct a perpendicular to DC at C intersecting BF (extended) in point E.
5. Join E to D and by bisection locate O, the center of a circle passing through D, B, C, E; ED is the diameter and angles DBE and DCE are the right angles on the semicircle.

6. $\angle CFE = \angle AFB = 90° - A/2 = (180° - A)/2 = (B+C)/2$, where $B = \angle ABC$ and $C = \angle ACB$ of the original triangle.
7. $\angle DEB = \angle DCB = C = \frac{1}{2}$ arc DB.
8. $\angle EDC = \angle EFC - \angle DEF = (B+C)/2 - C = (B-C)/2$.
9. Tan $(B-C)/2 = CE/DC = CE/(AC+DA) = CE/(b+c)$.
10. Tan $(B+C)/2 = CE/FC = CE/(AC-AF) = CE/(b-c)$.
11. From 9 and 10 we get

$$\frac{\text{Tan } (B-C)/2}{\text{Tan } (B+C)/2} = \frac{b-c}{b+c}.$$

A slight extension of the discussion enables us to prove Mollweide's equations.

12. $\angle CBF = \angle CDE = \frac{1}{2}$ arc $CE = (B-C)/2$.
13. $\angle BFC = 90° + A/2 =$ supplement of $\angle AFB = 180° - 90° + A/2$.
14. Applying Law of Sines we get

$$\frac{\text{Sin } \angle CBF}{FC} = \frac{\text{Sin } \angle BFC}{BC}$$

or

$$\frac{\text{Sin } (B-C)/2}{b-c} = \frac{\text{Sin } (90° + A/2)}{a} = \frac{\text{Cos } A/2}{a}.$$

CITIZENSHIP EDUCATION TO MEET PROPAGANDA THREAT URGED BY STUDEBAKER

United States Commissioner of Education John W. Studebaker made known August 22 that he has asked the chief school officers of the 48 States, outlying possessions and territories to reenforce citizenship education throughout the schools of the nation to make Americans, young and old, "alert to the meaning of events and to the tactics of the aggressors."

Specifically Commissioner Studebaker urged as practical measures of defense:

"*First*, we must once and for all eliminate illiteracy.

"*Second*, we must vigorously educate the foreign born and foreign language groups in the history and principles of American democracy. National and State leadership of organized education in this field is essential.

"*Third*, we must enable today's adults to catch up with modern problems and to understand them. This can be done through practical and systematic study and discussion. Civic illiteracy is an open invitation to a Fifth Column of American propaganda."

In forwarding a memorandum of suggestions to State directors of education Commission Studebaker urged that they report to him on actions or proposals initiated within their systems. He expects to relay back to all States the most promising ideas and plans received by the U. S. Office of Education for advancing citizenship education for national defense.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Forty-Fifth Meeting

BROWN UNIVERSITY
Providence, R. I.

Saturday, May 18, 1940

PROGRAM

10:15 Meeting of the Executive Committee.
10:30 Business Meeting.
Report of the Nominating Committee.
Election of Officers.
10:45 Report of Committees.
New Books and Magazine Literature.
Mr. Richard Porter-Boyer, Chairman.
New Apparatus.
Dr. Andrew Longacre, Chairman.
11:15 Address of the Vice-President.
Mr. Thomas A. Pickett.
12:00 Greetings: Professor R. B. Lindsay, Chairman of the Department of Physics, Brown University.
Address: "The Photographic Reproduction of Color."
Professor Carl W. Miller.
1:00 Luncheon, Pembroke College.
2:30 Address: "The Production of Metallic Mirrors by Evaporation."
Professor Alfred B. Focke.
3:30 Inspection of the Laboratory.

The laboratory will be open to members of the association for inspection, and it is hoped that many members will stay to see the advanced laboratory experimental equipment, as well as the research work being carried on in the department. The latter includes primarily electronics research in a high vacuum, and work in acoustics, particularly supersonics. Professor H. E. Farnsworth will be in charge of the exhibition of teaching and research apparatus.

Report of the Nominating Committee of the Eastern Association of Physics Teachers for 1940–1941

President—John P. Brennan, Somerville High School, Somerville, Mass.
Vice-President—John L. Clark, Chapman Technical High School, New London, Conn.
Secretary—Carl W. Staples, Chelsea High School, Chelsea, Mass.
Treasurer—Preston W. Smith, 208 Harvard St., Dorchester, Mass.
Executive Committee:
Everett J. Ford, English High School, Boston, Mass.
Lawrence A. Howard, East Boston High School, East Boston, Mass.
Robert W. Perry, Malden High School, Malden, Mass.

Respectfully submitted,
Burton L. Cushing, Chairman
William W. Obear

The above-named were elected for the ensuing year.

Report of the Committee on New Apparatus

Dr. Andrew Longacre, Chairman

Mr. Albert A. Griffin demonstrated an automatic Boyle's Law tube. It

was of the flexible type, the closed tube being movable. Two meter sticks were mounted side by side on the standard between the tubes, and were so arranged as to slide up and down in grooves. The mercury is levelled at the start and the meter sticks are adjusted to the levels in the closed and open tubes. As a class operation the pupils read the meter sticks getting a direct reading for the length of the air column and the height of the mercury in the open tube, thus eliminating subtraction and saving time. The greatest variation is $\frac{1}{2}$ of one percent, even the poorer pupils getting results within this limit.

Mr. Albert R. Clish of Belmont Junior High School showed a small stroboscope. It is contained in a case about $8'' \times 8'' \times 4''$ in size with a slot in each of the larger sides. It has a small reversible motor. In use it is lined up with lenses and a small arc light.

Mr. A. H. Dailey and Mr. W. W. Clark demonstrated a small oscilloscope, and some of its class-room uses. Among these were sine curve of alternating current, using a substation, and D.C., full wave rectification.

With an ordinary battery charger a curve showing half-way rectification was shown. A tungar rectifier with four lights for a load was used.

A microphone with a telephone transmitter and transformer attached, and with 2 dry cells, gave a curve upon which sound waves could be superposed, illustrating fundamentals and overtones. Whistles, tuning forks, and other sources of sounds were used. Beats were illustrated by two people whistling off-key.

Dr. Longacre showed a student-form interferometer soon to be placed on the market.

Professor R. B. Lindsay, Chairman of the Department of Physics at Brown University gave a cordial welcome to the association, saying that all teachers of science have a common bond, and should seek to make their teaching as effective as possible. Science, he said, is again on the defensive, and many critics are blaming it for chaotic conditions in the world, saying that it is too disinterested, or not interested in the fundamental problems of human life, that it makes thousands do uninteresting work, or deprives them of work altogether, and the like.

These critics overlook the benefits of its applications to the betterment of human society. Yet this is a serious problem, and has an important bearing on the teaching of physics.

One should have a philosophy in the teaching of this subject, and should not neglect its cultural aspects. There is great beauty, cultural value, and intellectual satisfaction in this science, leading to greater understanding of nature and her ways. Lives of scientists of the past show how they felt its cultural aspects. The fact that color approaches near to art, and the part that mirrors play in telescopes accentuating the part that Physics has in the study of the universe, were two examples of cultural applications.

THE PHOTOGRAPHIC REPRODUCTION OF COLOR

PROFESSOR CARL W. MILLER

Color photography should be of value to Physics teachers both as a means of stimulating interest in Physics and as a remarkable example of the power of modern methods of scientific research. All of the fundamental

ideas which are involved in color photography have been known for nearly eighty years. The development of practical methods has, however, been the contribution of intensive research during the past decade.

There are two experiments which can very well be shown to secondary school classes. The first is the historical experiment which James Clark Maxwell, one of the greatest physicists of all time, showed to the Royal Society in 1861. He made three photographs of a piece of ribbon through three color filters which he improvised from suitable solutions, each solution permitting the passage of approximately one third of the spectrum. He then made positive transparencies from each of the three negatives so obtained, and projected them from three separate lanterns in such a manner that the three images were superposed in correct register on the screen. The same filtering solutions which were used in taking the original negatives were placed in front of the respective lanterns. In this fashion the three primary colors, red, green, and blue-violet, were thrown on each part of the screen in such proportions as to reproduce approximately the original colors of the ribbon. Maxwell was forced to perform this experiment under very great handicaps which no longer exist. Dyed gelatin filters having ideal transmissions for this purpose, such as the standard A, B, and C5 Wratten filters of Kodak manufacture, are now available at small cost. The plates which Maxwell used were almost wholly insensitive to the yellow, orange, and red, and required excessively long exposure to yield even the faintest record of these colors. Today excellent panchromatic films of high speed and almost equal sensitivity throughout the spectrum are available for all cameras. The task of making the three negatives which separate in this manner the primary colors, is therefore, an elementary operation which can now be easily performed by anyone who owns a camera. If the separations are made with a miniature camera which takes 35 mm. films, contact positives can be printed on positive film. These positives can then be attached by Scotch tape to the circular framing apertures of the triple lantern which the Central Scientific Company sells for color demonstration purposes, and can then be projected in the proper way.

Such a method of reproducing color is known as an additive process, since the image on the screen is formed by the superposition or addition of three beams, each of which produces the psychological effect appropriate to its third of the total spectrum.

In 1862, the year after Maxwell's historic demonstration, Louis Ducos du Hauron submitted to the French Academy a paper in which he outlined a variety of methods of color photography. These suggested methods, which include the essential features of all which have been developed up to the present time, may be divided into two groups; additive processes which superpose on a dark background three independent primary colored images, as was done in the Maxwell demonstration; and subtractive processes, which, beginning with a white screen, subtract each of the primaries successively from the white light in such a manner as to leave in each area of the picture the appropriate amount of each color.

The second of the two experiments which can readily be shown to high school classes is a demonstration of this subtractive method. The same separation negatives can be used which were made for the additive demonstration. In the positive transparency which was made from the red filter negative, the darker areas represent parts of the subject which contained little or no red. They are therefore, the areas from which red should be subtracted if the image is to be formed on a white background. This positive must, therefore, be reproduced in a dye or pigment which has the property of absorbing the red third of the spectrum but of transmitting as freely as possible the other two thirds. Such a color is said to be complementary to the red of the filter; it appears to the eye as blue-green, and is usually known as minus-red. The green filter negative should similarly be reproduced as minus-green or magenta, and the blue filter negative in minus-blue or yellow. These colors, blue-green, magenta, and yellow, are known as subtractive primaries in contradistinction to the additive primaries, orange-red, green, and blue-violet, which are used for the taking filters. Thanks to the research work of their organization, it is now possible to obtain from the Defender Photo Supply Company metallic toners which can easily be used to convert the black silver image on the positive film into salts which possess quite accurately the desired spectral characteristics. If these toners are used, the blue-green image is composed of Prussian blue, the magenta of nickel dimethylglyoxime, and the yellow of cadmium sulphide. Having made in this way the three primary colored transparencies, they can be hinged together by Scotch tape in such fashion that each may be held by itself in the projection lantern or brought into registry to demonstrate the way in which the final colors are formed.

The importance of this last demonstration lies in the fact that all our modern methods of color photography, with the single exception of Dufaycolor film, are subtractive processes, in which there are always superposed three primary colored images, which have been made from negatives taken through the appropriate primary colored filters. In the case of Kodachrome these three negatives are made in three separate layers on a single film base, and are reversed and redeveloped to the proper colors by an elaborate processing technique. All of the present methods of making color reproductions on paper, however, still require the making of three separate primary color images and their subsequent assembly into a single print. It is common knowledge, for example, that in the so-called photomechanical processes of lithography and photo-engraving three (usually four for reasons inherent in the photomechanical processes) separate printing plates are used, which lay down the primary images successively in three passages through the press.

The development of satisfactory photographic methods of forming and assembling these primary color images has been very largely the achievement of intensive research during the past decade. Du Hauron expounded all of the ideas developed in the preceding paragraphs in his paper to the French Academy in 1862. He suggested also the use of the carbon process

to form the individual color elements from the proper primary colored pigments. During many years of subsequent experiment, however, he was hopelessly handicapped by the complete absence of panchromatic emulsions. With the discovery of new sensitizers about ten years ago, which led to the development of our present fast panchromatic films and their almost universal use in all branches of photography, the demand for purely photographic methods for making color prints became great enough to stimulate the necessary intensive research. As a consequence three satisfactory methods emerged; the one to which reference has already been made in which metallic toning methods are used, and which is known commercially as the Chromatone process; the trichrome carbro process, which is a modern development of the carbon process suggested by du Hauron; and a method in which the images are formed by the transfer of dye from a gelatin relief to a sheet of gelatin coated paper. These methods are none of them new, but they suffered from fundamental practical difficulties until well within the past decade. Thus in the metallic toning method no satisfactory magenta toner was known until the recent research work of the Defender Company. The assembly of the three pigment images in the carbro process demanded that they be formed on a transparent material such as celluloid to facilitate registration. For half a century the formation of such pigment images on celluloid or glass has been attended with the greatest uncertainty due to their tendency to frill away during the necessary manipulations. Only within the past four years have these difficulties been overcome. Similarly the dye imbibition processes have suffered from difficulties inherent in the tendency of these images to bleed and in the difficulty of securing quantitative transfer of the dye from the matrix to the paper support. The overcoming of these difficulties must be credited to the research work of the Kodak Company during the past few years.

These processes will probably play an important role in our future graphic art. They have now been brought to the point where they can be used successfully by high school teachers of physics and the more competent of their students. They are, furthermore, of absorbing interest, and should prove of great value in training and stimulating both scientific and artistic capacities.

PRODUCTION OF MIRRORS BY EVAPORATION OF METALS IN A VACUUM

DR. ALFRED B. FOCKE

During the past few years interest in the production of mirrors by the evaporation of metals in a vacuum has become very widespread. A simple apparatus to form such mirrors is described here. The principle of the apparatus is exactly that developed by Strong[1–4] in California.

[1] J. Strong, *Publ. A. S. P.*, 46, 18 (1934).
[2] J. Strong, *Phys. Rev.*, 46, 326 (1934).
[3] J. Strong, *Phys. Rev.*, 48, 480 (1935).
[4] J. Strong, *Phys. Rev.*, 49, 291 (1936).

It consists of a chamber formed by a steel base 18″ in diameter and 1″ thick on which a 12″ bell-jar rests. The chamber is evacuated by an Apiezon oil diffusion pump backed by a Megavac pump. The current leads for heating the filament are brought through the steel base by means of spark plugs. It is necessary to obtain a vacuum of about 10^{-3} to 10^{-4} mm. of mercury. This is about the pressure at which it becomes no longer possible to pass an electric discharge through the remaining gas.

The form of the filament is governed by the metal to be evaporated. In the case of most metals it consists of a small conical spiral of 15 mil tungsten wire which acts as a container for the metal as well as a heating element. If the turns of the spiral are fairly close together surface tension will prevent the molten metal from falling through it. In the single case of aluminum the filament takes the form of a helix of four turns. It is made from four pieces of 15 mil tungsten wire, each about 6½ inches long, wound together to form a cable. The four turns are formed by wrapping the wire around a 3/8-16 stove bolt at red heat. If made properly there will be about 1″ of wire left on each end for connection to the supports. It is charged with two pieces of 1/16″ aluminum wire 3/8″ long. When the aluminum is melted it forms an alloy with the tungsten, thus preventing the aluminum from falling off the wire. If a smaller diameter tungsten wire, or a larger charge of aluminum is used, there is great danger of all the tungsten being dissolved in the aluminum, causing the filament to break. A current of 22 amperes at 4½ volts is used to heat the tungsten filament.

Small mirrors are very conveniently made using one filament only, the distance between filament to mirror depending on the size of the mirror and the uniformity of the coating that is desired. In case a large mirror is to be coated, the best procedure is to form a ring of filaments with a diameter at least as great as the greatest dimension of the mirror. The glass should be placed at a distance below the ring of filaments equal to the radius of the ring. In this way a uniform coating will be secured. It is, of course, necessary to have the glass chemically cleaned before applying the coating. It is helpful in addition to chemically cleaning, to bombard the surface of the glass with the discharge from a high voltage source after it has been placed in the vacuum chamber. This is most easily done by the use of a leak-testing coil which will permit the bombardment of the glass through the bell-jar when the pressure in the chamber has been reduced to about 10^{-2} mm. of mercury. This pressure is characterized by the beginning of fluorescence in the glass when the discharge is being used.

By following this procedure mirrors have been successfully produced using the metals aluminum, silver, gold, copper, tin, and many others.

The correct deduction from the Second Law (of Thermodynamics) is not that the present state of the universe could not have happened by chance, but that most of eternity is dull.—J. B. S. HALDANE

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve the problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and Solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to theproblem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1652, 57. *Malcolm Kirk, West Chester, Pa.*

1651. *C. C. Hunt, Cedar Rapids, Iowa, John F. Wagner, Chicago.*

1650. *John F. Wagner, Chicago.*

1658. *Proposed by I. N. Warner, Platteville, Wis.*

By two different methods find the volume of a railway embankment across a valley with the dimensions; width, at top, 20; at base, 45; height, 11; length, at top, 1020; length at base, 960.

First Method by Glenn Larsom, Los Angeles City College

By Prismoidal formula:

$$V=\frac{h}{6}(B+4M+b),$$

where h = altitude of solid,
B = area lower base,
M = area section midway between bases,
b = area upper base.

$$V=\frac{11}{6}(960\times45)+(4\times32.5\times990)+(20\times1020)$$

$$V=352{,}550.$$

Second Method by John F. Wagner, Lewis Institute, Chicago

Cut the figure to make a regular prism with top and bottom lengths,

each 1020′. To do this we had to add a figure with triangular cross section $30' \times 11'$ and $20'$ deep and 2 pyramids each of bases $30' \times 25'/2$ and height of $11'$

$$\text{Volume} = \frac{20+45}{2} \times 11 \times 1020 - 2\left[\frac{1}{2}\ 30 \times 11 \times 20 + 2\left(\frac{1}{3} \times 30 \times \frac{25}{2} \times 11\right)\right]$$

Volume = 352,550 cu. ft.

Solutions were also offered by C. W. Trigg, Los Angeles City College, I. N. Warner, Platteville, Wisconsin, Hobson M. Zerbe, Wilkes-Barre, Pa., George J. Ross, Brooklyn, N. Y.

1659. *Proposed by F. H. Wade, Lewis Institute, Chicago, Ill.*

A tool maker is required to arrange two 8″ by 4″ ellipses with major axes parallel and 2.50″ apart. Find the distance between minor axes if shortest distance from one ellipse to the other is to be exactly 1 inch.

Solution by C. W. Trigg, Los Angeles City College

Method I.

Let the equations of the ellipses be $x^2+4y^2=16$ and $(x-h)^2+4(y-2.5)^2=16$. The shortest distance between these non-intersecting ellipses will be along a line segment normal to both ellipses, and hence perpendicular to the tangents to the ellipses at the points of intersection. Now the line $y=mx \pm \sqrt{a^2m^2+b^2}$ is tangent to the ellipse $b^2x^2+a^2y^2=a^2b^2$ for all values of m. Hence the lines $y=mx+2\sqrt{4m^2+1}$ and $y-2.5=m(x-h)-2\sqrt{4m^2+1}$ are tangent to the ellipses, respectively. Here the signs before the radicals are so chosen that the parallel tangents will fall between the ellipses, and m will be negative.

When y is eliminated between the equations of the first ellipse and its tangent, the quadratic $(4m^2+1)x^2+16mx\sqrt{4m^2+1}+64m^2=0$ is secured. Since this has equal roots, the coordinates of the point of tangency are $(-8m/\sqrt{4m^2+1},\ 2/\sqrt{4m^2+1})$. Similarly, the point of tangency on the second ellipse is $(h+8m/\sqrt{4m^2+1},\ 2.5-2/\sqrt{4m^2+1})$.

The line joining these two points is the normal with a slope of $-1/m$, so

$$\frac{2.5-4/\sqrt{4m^2+1}}{h+16m/\sqrt{4m^2+1}} = -\frac{1}{m}. \tag{1}$$

By applying the distance formula, the distance between the lines is found to be

$$(2.5-mh-2\sqrt{4m^2+1})/\sqrt{m^2+1}-2\sqrt{4m^2+1}/\sqrt{m^2+1}=1. \tag{2}$$

Solving (1) and (2) for h, we have

$$h = \frac{-m(2.5\sqrt{4m^2+1}+12)}{\sqrt{4m^2+1}} = \frac{2.5-4\sqrt{4m^2+1}-\sqrt{m+1}}{m}. \tag{3}$$

When this is rationalized, we secure

$$10000m^8+9000m^6-10671m^4-8990^2+825=0.$$

Upon substituting $M/10$ for m^2, this is converted into

$$M^4+9M^3-106.71M^2-899M+825=0.$$

Since m is to be real and negative we seek only the positive roots of this

equation, which by Horner's method are found to be 0.840357308 and 9.95457332746. To these correspond the values of m, 0.28989 and 0.997726. From (3), the corresponding values of h are found, namely 3.73 in. (for which value the ellipses intersect) and 7.858 inches (approximately), the required distance between the minor axes.

Method II.

It is evident that when the ellipses are 1 inch apart, a circle of radius, $\frac{1}{2}$ inch, will be externally tangent to both ellipses. From considerations of symmetry, it is further apparent that the center of this circle will be 1.25 inches from each of the major axes and $\frac{1}{2}h$ from each of the minor axes, which are h inches apart.

Let one of the ellipses be $x^2+4y^2=16$ and let the circle be $(x-\frac{1}{2}h)^2+(y-1.25)^2=0.25$. When y is eliminated between these equations, we secure

$$144x^4-384hx^3+(352h^2+2440)x^2-h(128h^2+2720)x+16h^4+680h^2+825=0.$$

Since the two curves are tangent, this equation has a double root. The condition that $ax^4+bx^3+cx^2+dx+f=0$ have a double root is that its discriminant vanish. The discriminant may be written in the convenient form,

$$\begin{aligned}&[128a^2(2af-c^2)+48ab(3bc-4ad)-27b^4]f^2\\&\quad+[6b^2d(3bc-ad)+16acd(9ad-5bc)+4c^3(4ac-b^2)]f\\&\quad+[(18abc-4b^3-27a^2d)d+c^2(b^2-4ac)]d^2.\end{aligned}$$

When the coefficients from the numerical equation are substituted in this discriminant formula, after much labor we secure

$$16h^8-2520h^6+156729h^4-4448360h^2+37781700=0.$$

Let $H=2h^2$, whence $H^4-315H^3+39182.25H^2-2224180H+37781700=0$. This equation has two imaginary roots and two positive roots, one between 18 and 32, whence $9<h^2<16$ and $3<h<4$. For this value the ellipses intersect. The other positive root is found by Horner's method to be 123.5114440960, to which corresponds the value of $h=75848$ (approximately) inches between the minor axes.

The pattern maker, however, would have approached the problem by making a pattern of the ellipse. Then he would have laid out two parallel lines 2.5 inches apart and drawn an ellipse with major axis on one of the lines. Then he would have slid the pattern along the other line until it and the drawn ellipse were both tangent to a strip one inch wide with parallel edges and with scorings perpendicular to the edges.

A solution was also offered by Hugo Brandt.

1660. *Proposed by Stephen Droemus, Willard, N. Y.*

Show that every number and its cube when divided by 6 leaves the same remainder.

Solution by M. Freed, Wilmington, Calif.

Let n represent any integral number and $n=6k_1+r_1$

$n^3=6k_2+r_2$ with k_1, k_2, r_1, r_2, being 0 or integral numbers less than 6.

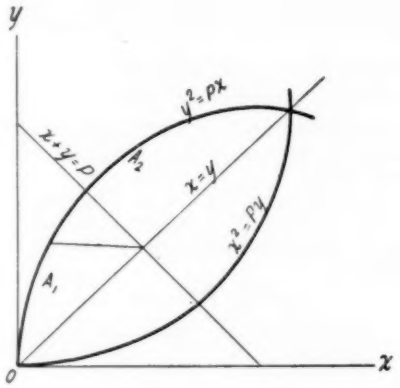
Then

$$n^3-n=n(n-1)(n-2)=6(k_2-k_1)+r_2-r_1.$$

Since $n(n-1)(n-2)$, being the product of three consecutive integral numbers, is divisible by 6. r_2-r_1, being less than 6 must equal 0. Then $r_2-r_1=0$, $r_2=r_1$.

Solutions were also offered by Howard R. Harold, Tonkawa, Oklahoma, Julius Freilich, Brooklyn, N. Y., Malcolm Kirk, West Chester, Pa., Alan Wayne, New York City, John F. Wagner, Lewis Institute, Chicago, George J. Ross, Brooklyn, New York.

1661. Editor's note: George J. Ross, Brooklyn and B. Felix John, Brooklyn, present partial solutions. The system of equations has no unique solution. The work is too complicated for space in this issue.



1662. *Proposed by Hugo Brandt, Chicago, Ill.*

In what ratio does the line $x+y=p$ divide the area that the curves $y^2=px$ and $x^2=py$ have in common?

Solution by Arthur Danzl, Collegeville, Minn.

Since $y=x$ is the line of symmetry for the figure containing the area in question, it is sufficient to consider the area bounded by the curves $y^2=px$ and $y=x$.

The points of intersection of the line $x+y=p$ with the curves $y^2=px$ and $y=x$ are $[p/2(3-\sqrt{5}),\ p/2(\sqrt{5}-1)]$ and $(p/2,\ p/2)$ respectively. Calling the entire area bounded by $y^2=px$ and $y=x$ by A_0 and the segments of area by A_1 and A_2 where $A_0=A_1+A_2$, we have

$$A_0=\int_0^p\int_x^{\sqrt{px}}dy\,dx=\int_0^p(\sqrt{px}-x)dx=\frac{p^2}{6}$$

$$A_1=\int_0^{p/2}\int_{y^2/p}^{y}dx\,dy+\int_{p/2}^{p/2(\sqrt{5}-1)}\int_{y^2/p}^{p-y}dx\,dy$$

$$=\int_0^{p/2}\left(y-\frac{y^2}{p}\right)dy+\int_{p/2}^{p/2(\sqrt{5}-1)}\left(p-y-\frac{y^2}{p}\right)dy$$

$$=\frac{p^2}{12}+\frac{p^2}{12}(5\sqrt{5}-11)=\frac{5p^2}{12}(\sqrt{5}-2)$$

$$A_2=\frac{p^2}{6}-\frac{5p^2}{12}(\sqrt{5}-2)=\frac{p^2}{12}(12-5\sqrt{5}).$$

Therefore $A_1:A_2=(5\sqrt{5}-10):(12-5\sqrt{5})=5(1+2\sqrt{5}):19=1.44$.

Solutions were also offered by C. W. Trigg, Los Angeles, Malcolm Kirk,

West Chester, Pa., John F. Wagner, Chicago, and also by the proposer, and George J. Ross, Brooklyn, N. Y.

1663. *Proposed by John Meighan, Hillsdale, Mich.*

Prove that there is only one positive integer, n, such that 2^{n+2} is the product of two consecutive even integers.

Solution by Malcolm Kirk, West Chester, Pa.

(1) $$2^{n+2}=(2m)(2m+2)$$

expresses the imposed condition m and n being integers.

$$=4(m)(m+1)$$

$$2^n=m(m+1).$$

One of the two factors must be odd. 2^n is divisible by only one odd number, that is one. Therefore the only value that m can have is 1.

From (1) $2^{n+2}=8$, $n=1$.

Solutions were also offered by John F. Wagner, Chicago, M. Freed, Phineas Banning High School, Wilmington, Calif., Julius Frielich, Brooklyn, N. Y., George J. Ross, Brooklyn, N. Y., C. W. Trigg, Los Angeles, and also by the proposer.

PROBLEMS FOR SOLUTION

1676. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Show that in any triangle ABC

$$\frac{(b+c-a)\sin A}{1+\cos A}=\frac{(c+a-b)\sin B}{1+\cos B}=\frac{(a+b-c)\sin C}{1+\cos C}.$$

1677. *Proposed by John F. Wagner, Chicago.*

If x, y and z are not negative and if $3x/2+4y/3+5z/4=24$, between what two integers must the expression $3x+5y/2+12z/5$ lie?

1678. *Proposed by Clarence S. Warne, Romulus, N. Y.*

If a, b, c are in harmonic progression prove that

$$\left[\frac{a+b}{2a-b}-\frac{c+b}{2c-b}\right]>4.$$

1679. *Proposed by D. L. MacKay, New York.*

If in triangle ABC, $C=60°$ prove that the line joining the orthocenter and circumcenter when produced cuts BC at an angle of 60°.

1680. *Proposed by Hugo Brandt, Chicago.*

A point P is given either within or without the plane of an arbitrary rectangle $ABCD$. If lengths PA, PB and PC are equal to a, b, c respectively what is the length of PD?

1680.1. *Proposed by John F. Wagner, Chicago.*

Solve the equations

$$\frac{\sqrt[3]{x+y}-\sqrt[3]{x-y}}{\sqrt[3]{x+y}+\sqrt[3]{x-y}}=3$$

$$x^2+y^2=65$$

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

1658. *Eli Borok, David Cutsforth, Glenn Larson, William H. Pauly, Clay Perry, Ernest Wade, all of Los Angeles, Calif.*

1660. *Eli Borok, Julius Brandstatter, Glenn Larson, Harold Luxenberg, William H. Pauly, Clay Perry, Los Angeles.*

1662. *Eli Borok, Lawrence Cook, Roy J. Huff, Lawrence Klein, Glenn Larson, Clay Perry, Los Angeles.*

1663. *Eli Borok, Julius Brandstatter, William Pauly, Clay Perry, Los Angeles.*

SCIENCE QUESTIONS

October, 1940
Conducted by Franklin T. Jones,
10109 Wilbur Avenue, S.E., Cleveland, Ohio

DO YOU KNOW THE ANSWERS?

Readers are invited to propose questions preferably with brief answers.

101. What was the first plastic and who was its discoverer?
(You will find out if you read Alfred P. Sloan, Jr.'s "Adventures of a White Collar Man" in the *Saturday Evening Post* of August 17, 1940.)
102. What is the lightest strong metal?
103. What is a xanthate and what is its use?
104. What is a "magnetic mine"? Are they attracted from the bottom by an iron ship and do they pop up against the ship and explode?
105. What process in plant reproduction do insects often aid?
(Rosalyn Heck, GQRA, No. 335.)

Answers to Questions for May, 1940

91. Yes; X-rays pass through black paper readily. Lead and other metals hold them back.
92. Yes: rivers take more salt to the ocean each year.
93. No; a tidal wave is not the result of a tide but is caused by an earthquake or by change of atmospheric pressure moving from land to sea or sea to land.
94. A sponge is an animal and the bath-room sponge is its skeleton.
95. No man has descended to a depth of four miles in the ocean; the pressure is too great.

NEW QUESTIONS

896. *Suggested by 94 above—*
What is the pressure due to weight of sea-water at a depth of four miles, assuming a mean density of 1.025?

COLOR OF FLUORITES

897. *Proposed by Carrol C. Hall, Springfield, Ill. (GQRA, No. 326.)*

The mineral fluorite exists in many beautiful colors; yellow, purple, pink, rose, green, plum and amethystine. These are found in various combinations and some specimens are found colorless.

When any color of the mineral is strongly heated, the color vanishes, or when any color is pulverized, the powder is always white in color. The unsolved question: What is the source of color in fluorite?

NEW TEST IN CHEMISTRY—(Please Note Form)

895. *Continued from pages 591 and 592, June, 1940, issue of* SCHOOL SCIENCE AND MATHEMATICS.

Given by Brother Edward (GQRA, No. 136) at Central District Catholic High School, Pittsburgh, Pa.

(Please refer to the heading of the first instalment of this examination as given on page 591.)

Answer These in Left-Hand Column of Reverse Side of Answer Sheet

51. What is the characteristic group found in all *alcohols?* (formula only)
52. What is the characteristic group found in all *org. acids?*
53. What is the characteristic group found in all *aldehydes?*
54. What is the characteristic group found in all *amines?*
55. What is the characteristic group found in all *esters?*
56. What class of compounds is represented by the general formula RX?
57. What class of compounds is represented by the general formula R-O-R?
58. What class of compounds is represented by the general formula R-COOH?
59. To what class of compounds does this substance belong—(H-CHO)?
60. What substance has the formula C_2H_2 (graphic formula H-C≡C-H)?
61. What is our chief source of paraffin wax (name natural product)?
62. What natural product is the chief source of methane and ethane?
63. What name is given to the process of a solid passing directly into the gaseous state without first becoming a liquid? (example Dry Ice)
64. Substances that form hydrogen ions in water solution are known as what kind of substances?
65. Substances that form hydroxyl ions in water solution?
66. When electrolytes dissolve in water the molecules separate into ions. What name is given to this separation?
67. Who proposed the theory that molecules of electrolytes break up?

68 to 75.—List in correct order the first *eight members of the paraffin series.* (Names are required—*not* formulas.)

Answer These in Right-Hand Column of Reverse Side of Answer Sheet

76. What reagent would you use in the test for carbon dioxide gas?
77. Which one of the following is *not soluble?* (NH_4Cl, $CaCl_2$, HgCl, $HgCl_2$) *Write formula.*
78. Give the formula of benzene.
79. Give the chemical equation for the combustion of carbon.
80. A sample of gas smells like rotten eggs. It is SO_2, NH_3, CO or H_2S?
81. Which is heavier—Carbon dioxide or Carbon monoxide?
82. Which of the two gases mentioned in #81 is least soluble in water?
83. For what other purpose besides jewelry are diamonds used?
84. What rating in the scale of hardness is the diamond? (Give hardness number)
85. Is carbonic acid harmful to the human system? (YES or NO)

86. What is the formula of carbonic acid?
87. What gaseous substance is given off when soft coal is heated in the absence of air?
88. What liquid substance is distilled over in the same process?
89. What process produces large quantities of carbon dioxide as a by-product, and is the source of most of the CO_2 used in making Dry Ice?
90. Compounds that contain only the two elements hydrogen and carbon are called by what name?
91. What compound in organic chemistry is used in "moth balls"?
92. Members of the paraffin series that have all carbon bonds filled with hydrogen atoms are said to be —— compounds.
93. What kind of substances are the commercial products "DUPRENE and NEOPRENE? (*Refrigerants, Dyes, Synthetic Rubbers, Solvents* or *Plastics?*)

94–95–96–97: On these four lines place the *graphic* formula of *benzene* (show all bonds etc.).

98. What is the molecular weight of $CaCO_3$? Atomic Wts. Calcium = 40
Oxygen = 16
Carbon = 12
Hydrogen = 1
99. What is the molecular weight of CO_2?
100. How many grams of CO_2 can be made by treating one pound of $CaCO_3$ with sufficient acid? (1 lb. = 454 g.)
(unbalanced equation) $CaCO_3 + HCl \longrightarrow CaCl_2 + H_2O + CO_2$
Answer to the nearest whole number.

NAME_____ CLASS____B NUMBER_____

Place your answer sheet in a separate pile. All question sheets must be RETURNED

ANSWERS TO OTHER QUESTIONS

886. *Proposed by Arthur L. Hill, (GQRA), No. 115, Peru, Neb.*

Given two metal spheres, same color (perhaps painted so as not to disclose identity), one solid the other with a hollow place in it, presumably of the shape of a concentric sphere; both weigh exactly the same and both have the same radius but the metals from which each is made are different.

How could one determine of the two which one was hollow? (SCHOOL SCIENCE AND MATHEMATICS, April 1940, page 391)

Answer by John Ellis Evans, Rio Grande College, Rio Grande, Ohio (Elected to the GQRA, No. 344)

If the two spheres are rolled down an incline simultaneously, the solid sphere will have a greater acceleration because of its smaller moment of inertia.

890. *Proposed by Arthur Berman, (GQRA, No. 377) and answered.*

How can astronomers find out whether a star is moving directly towards us or directly away from us and even calculate its speed?

The answer of course is by the Doppler Effect, but the answerer is expected to define this effect and show how it can be applied in the question. We can calculate its speed by observing the shift in the Fraunhofer lines of a star's spectrum.

I am a student of The Bronx High School of Science.

880. *Proposed by Brother Felix John (GQRA, No. 17).*
Answers by Alan Wayne (GQRA, No. 314).

(1) Is it true that the earth receives only a two-billionth part of the radiation from the sun? How figure it?

From page 278 of *The Principles of Aerography* by A. McAdie (1917, Rand McNally & Company), we note that: "the amount of energy varies inversely as the square of the distance from the sun, also with the angle of incidence of the rays, and according to duration." If we confine our computation to energy *reaching* the earth as a whole, rather than *absorbed* by it, we can neglect the angle of insolation; then the sun is about 1,000,000 miles away, and the earth presents only half its surface to the sun at a time, the energy *arriving at* the earth is about $\frac{1}{2}\,(1/1{,}000{,}000)^2$ or about a two-trillionth part of the energy radiated from the sun in the same interval of time. The amount absorbed is of course much less than this.

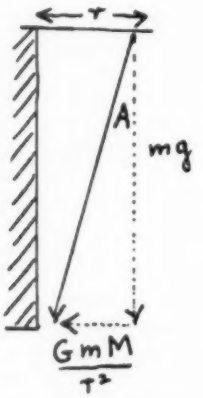
(2) Are two plumb lines parallel? Why?

The plumb lines (ignoring the mutual effect of the plumb bobs) if extended earthward will intersect at the earth's center of gravity. They are merely vertical.

(3) In laying up an eight-story wall can the corner be kept vertical by the plumb line? Why?

The force of attraction between the wall and the plumb bob is given by $F = GMm/r^2$ where G = gravitational constant, r = distance of separation of the centers of gravity, and M, m, the respective masses. The angle A by which the plumb line differs from the vertical is given by $\tan A = GM/gr^2$ where g = acceleration of gravity. Assuming an 8-story wall to have a mass of 10,000 grams (about 10 tons weight) and the center of the bob to be about 5 cm (2 inches) from the wall, $\tan A = \dfrac{6.66\times10^{-8}\times10^{4}}{981.\times25} = .00000003.$

whence A = about 0.006 seconds. Assuming the wall to be about 80 feet high, this means the plumb bob will be pulled over toward the wall by about 0.00003 inches—a NEGLIGIBLE amount! The bricklayer need have no fear.



WANTED

QUESTIONS—TESTS—EXAMINATION PAPERS—ANSWERS

Questions your pupils should answer correctly but do not.
Questions that aroused discussion in your classes.
The fun as well as the serious in science teaching.

Join the Guild of Question Raisers and Answerers (GQRA)
Pupils and classes are eligible as well as teachers and outsiders
Three hundred and fifty are already members!

GQRA—NEW MEMBERS, October, 1940

344. *John Ellis Evans, Rio Grande College, Rio Grande, Ohio*
345. *Elinor Bruskiewitz*
346. *Ruth Dziekan*
347. *Florence Maciolek*
348. *Marion Pukek*
349. *Lydia Talamentes*
350. *Lorraine Thoma*

all of Mercy High School, Milwaukee, Wis.

THE CHEMISTRY EXAMINATION OF THE COLLEGE ENTRANCE EXAMINATION BOARD

In 1937 the College Entrance Examination Board appointed a Commission to revise the requirements for the one-unit examinations in physics and chemistry. The membership of the Commission, which submitted its report at the April, 1940, meeting of the Board, follows:

Dean John T. Tate, University of Minnesota (Chairman)
Doctor Otis E. Alley, High School, Winchester, Mass.
Mr. Raymond B. Brownlee, Stuyvesant High School, New York City
Dean Janet H. Clark, University of Rochester
Mr. John C. Hogg, Phillips Exeter Academy, Exeter, N. H.
Professor Erwin B. Kelsey, Yale University
Mr. Alfred R. Lincoln, Technical High School, Springfield, Mass.
Professor Duane E. Roller, Hunter College
Professor Francis W. Sears, Massachusetts Institute of Technology
Professor Mary L. Sherrill, Mount Holyoke College
Mr. Howard A. Tabor, Hotchkiss School, Lakeville, Conn.

The report consists of proposed syllabi in physics and chemistry. The chemistry syllabus is printed below in the belief that it will be of interest to all teachers of chemistry. This syllabus, together with the physics syllabus, will be presented to the Board for action in October. In the meantime the Executive Secretary of the Board will welcome suggestions and criticisms from those interested. Communications should be addressed to the office of the College Entrance Examination Board, 431 West 117th Street, New York City.

The Chemistry Syllabus

The following suggested redefinition of the requirement in chemistry indicates the nature and extent of the *basic* preparation considered necessary for college work. It is estimated that from two-thirds to four-fifths of the school year will be required to cover the basic topics suggested in the minimum syllabus given by Part I and Part II. Part III is intended to

show how the basic material of Parts I and II can be amplified. Additional specific material designed to meet the needs of the community and adapted to the level of the student body should also serve to enrich the basic course. Questions on topics beyond this suggested area will not be included since it is felt that the science will be more effectively taught if the instructor is given greater latitude in the selection of topics.

The syllabus is divided into two sections:

(1) a minimum syllabus, Part I and Part II;

(2) an extension syllabus, Part III, which is subdivided into

(*a*) commercial chemistry,

(*b*) theoretical chemistry, and

(*c*) organic chemistry.

Candidates will be examined on the minimum syllabus only. Quantitative problems may be set upon those topics marked with an asterisk (*).

In order that the objectives of the course of study may be fully realized, it is essential that the study of chemistry be accompanied by individual laboratory work as well as by class demonstrations. The laboratory work should occupy approximately one-third of the time devoted to chemistry and it should continue throughout the whole course. A list of experiments is not submitted as it is believed that the experiments will need to be varied according to the facilities of a particular institution. The arrangement of the syllabus does not imply a teaching sequence.

Part I. General Chemistry

I. Chemical Changes.
- A. Element, compound, mixture.
  1. Chemical change versus physical change.
  2. Significance of terms—atom, molecule, radical.
  3. Types of chemical reactions.
  4. Electrochemical series—limited to displacement reactions.
- B. Balancing of simple equations.
- *C. Quantitative relationship in chemical reactions.
  1. Significance of symbol, formula, equation.
  2. Laws of combining proportion.
  3. Percentage composition.
  4. Problems based on chemical equations:
     (*a*) weight relationships,
     (*b*) volume relationships.
  5. Neutralization (quantitative). Normal solutions.

II. Physical Properties of Solids, Liquids, and Gases.
- A. Kinetic molecular theory—relation between temperature and speed of molecules. Differences between solids, liquids, and gases from kinetic molecular viewpoint.
- *B. Gases.
  1. Effect of changes of temperature and pressure on the volume of gases. Explanation in terms of the kinetic theory.
  2. Partial pressures of gases in a mixture—related only to vapor pressure of water.
  3. Reduction to standard conditions (including vapor pressure of water).

4. Avogadro's Law: derivation of gram molecular volume from a knowledge of the density and molecular weight of a gas.

III. Periodic Law.
Brief treatment giving variation in properties of the elements as one proceeds horizontally and vertically through periods and families. Anomalies.

IV. Structure of Atoms.
- A. Units of structure.
  Proton, neutron, electron, characterization as to mass and charge.
- B. Atomic number. Nuclear charge and arrangement of electrons (hydrogen through calcium).
  Isotopes (hydrogen, chlorine).
- C. Explanation of periodicity in properties of elements in terms of atomic structure.
- D. Ionic valence and its relationship to inert gas structure (hydrogen through calcium).
- E. Chemical combination explained in terms of atomic structure.
  1. Electrovalence—combination and displacement; reactions in terms of electron transfer (oxidation-reduction).
  2. Covalence—sharing of electrons in formation of un-ionized molecules.

V. Electrolytes.
- A. Physical evidence of dissociation in fused salts and bases and in water solutions.
- B. Complete dissociation of salts and strong bases.
- C. Ionization of acids.
  1. Ionization of acids by reaction with water. Distinction between a proton and the hydrated hydrogen ion (hydronium ion).
  2. Degree of ionization of weak acids—ionic equilibrium.
- D. Completion of ionic reactions by:
  1. Formation of a slightly ionized product;
  2. Formation of an insoluble gas or solid.
- E. Hydrolysis of salts (reaction of ions with water).
- F. Electrolysis of water solutions.

Part II. Descriptive Chemistry

In general, the study of any element should be developed in the following sequence: history, occurrence, preparation (most important laboratory and commercial methods), properties (physical and chemical), uses, and identification. Historical treatment should be limited to cases where it offers a sound teaching approach and where it is of particular significance in the study of an element; for example, as an introduction to oxygen and hydrogen.

Similarly, the study of the important compounds of the elements should include preparation, properties (physical and chemical), uses, and identification.

As illustrative of a typical study of an element and its important compounds, the topic *Nitrogen* is given in expanded form at the end of Part II.

I. Chemistry of Some Nonmetals and Their Common Compounds.
- A. Oxygen.
- B. Hydrogen.
- C. Water.
  1. Composition by weight and volume.
  2. Purification.
  3. Chemical reactions:

(*a*) With oxides, basis of classification of metals and nonmetals.
(*b*) With salts to form hydrates.
4. Solutions:
(*a*) Significance of terms—saturated, unsaturated, molar.
(*b*) Interpretation of solubility curves.

D. Carbon (allotropes).
1. Carbon dioxide and carbonic acid; types of carbonates; test for a carbonate.
2. Carbon monoxide.

E. Halogen family.
1. Chlorine; hydrogen chloride and hydrochloric acid; hypochlorous acid.
2. Bromine, iodine, fluorine, and the hydrogen compounds, as compared with clorine and hydrogen chloride.
3. Tests for chloride, bromide, and iodide ions.

F. Sulfur.
1. Hydrogen sulfide, sulfides.
2. Sulfur dioxide—sulfurous acid, sulfites, bisulfites.
3. Sulfur trioxide—sulfuric acid, sulfates, bisulfates.
4. Tests for sulfide, sulfite, and sulfate ions.

G. The atmosphere.
1. Air as a mixture.
2. Nitrogen and the rare gases.

H. Nitrogen compounds.
1. Ammonia—test for ammonium ion.
2. Oxides of nitrogen—nitric oxide and nitrogen dioxide.
3. Nitric acid.
Test for nitrate ion.

II. Chemistry of a typical metal.
A. Sodium and its compounds.
1. Sodium hydroxide.
2. Sodium chloride.
3. Sodium carbonate and sodium bicarbonate.
4. Sodium nitrate.

III. Nitrogen (Outlined in Expanded Form for Illustrative Purposes).
A. History.
B. Occurrence.
C. Preparation.
1. Atmospheric nitrogen.
2. Pure nitrogen.

D. Properties.
1. Physical.
2. Chemical.

E. Uses.
F. Compounds.
1. Ammonia.
(*a*) Laboratory preparation.
(*b*) Commercial preparation.
(1) Synthetic (Haber).
(2) Cyanamid.
(*c*) Ammonium compounds.
(*d*) Test for ammonium ion.
2. Oxides of nitrogen.
(*a*) Nitric oxide.
(1) Preparation by:
(a) oxidation of ammonia (Ostwald).

(b) reduction of nitric acid.
(2) Identification.
(*b*) Nitrogen dioxide.
(1) Preparation by:
(a) oxidation of nitric oxide,
(b) reduction of nitric acid,
(c) heating of nitrates.
(2) Identification.
3. Nitric acid.
(*a*) Preparation.
(1) Laboratory.
(2) Commercial: oxidation of ammonia (Ostwald).
(*b*) Properties.
(1) Physical.
(2) Chemical.
(a) Reaction of concentrated and dilute acid on
(i) metals,
(ii) non-metals,
(iii) salts.
(*c*) Test for nitrate ion.
G. Nitrogen Cycle.

Part III. Extensions

Parts I and II give the basic material for preparation for college work. It is recommended that the basic material be supplemented by topics from Part III and also by various items of current and local interest.

I. Commercial Chemistry.
A. Chemistry of four metals and their common compounds: aluminum, iron, zinc, and copper.
1. Occurrence and extraction of these four elements from their ores.
2. Simple reactions of these elements and identification of their ions.
B. Fuels.
1. Coal gas, producer gas, water gas.
2. Acetylene.
3. Petroleum and natural gas; distillation and cracking process.
II. Theoretical Chemistry.
A. 1. Oxidation-reduction by electron transfer, as illustrated in the reactions of Part II.
2. Ozone, hydrogen peroxide, other peroxides, atomic hydrogen.
*B. Determination of:
1. Equivalent weight.
2. Molecular weight.
3. Application of these to the determination of atomic weights.
C. Equilibrium, mass action law and principle of Le Chatelier as applied to:
1. Synthetic ammonia (Haber process),
2. Contact process for preparation of sulfuric acid,
3. Common ion effect with weak electrolyte.
III. Organic Chemistry.
A. Simple organic reactions.
B. Foods.
1. Components: carbohydrates, fats, proteins, vitamins.
2. Hydrolysis. Uses of starch and sugar.
3. Fermentation.

PROPOSED REVISION OF THE REQUIREMENTS FOR THE COLLEGE ENTRANCE EXAMINATION IN PHYSICS

The commission appointed by the College Entrance Examination Board to revise the examination requirements in physics and chemistry has formulated the following syllabus for a one-year secondary-school course in physics. This suggested redefinition of the requirement in physics indicates the nature and extent of the basic preparation considered necessary for college work. It is estimated that from two-thirds to four-fifths of the school year will be required to cover the basic topics suggested in the minimum syllabus given by Part I. Candidates will be examined on the minimum syllabus only.

Part II is intended to show how the basic material of Part I can be amplified. Additional specific material designed to meet the needs of the community and adapted to the level of the student body should also serve to enrich the basic course. Questions on topics in this suggested area will not be included since it is felt that the science will be more effectively taught if the instructor is given greater latitude in the selection of topics.

In order that the objectives of the course of study may be fully realized, it is essential that the study of physics be accompanied by individual laboratory work as well as by class demonstrations. The laboratory work should occupy approximately one-third of the time devoted to physics and its should continue throughout the whole course. A list of experiments is not submitted as it is believed that the experiments will need to be varied according to the facilities of a particular institution. The arrangement of the syllabus does not imply a teaching sequence.

PART I

It is assumed that the student is familiar with the geometric relations connecting length, area and volume, and with the common English and metric units of these quantities.

MECHANICS

Basic concepts

Weight
  Units: pound; gram

Force: generalization of weight concept
  Units: pound; gram
  Hooke's law: relation between force and extension or compression; measurement of force and weight by spring balance

Weight per unit volume or "density"
  Units: pound per cubic foot; gram per cubic centimeter

Pressure: force per unit area
  Units: pound per square inch; gram per square centimeter

Fluids at rest

Pressure in a liquid
  Pressure at a point: the pressure is the same at all points at any given depth, and is the same in all directions at any given point

Force at a boundary surface: the force is perpendicular to the surface

Variation of pressure with depth: the pressure equals the product of the "density" and the depth
Force on vertical and horizontal boundary surfaces: the force equals the product of the average pressure and the area
Pascal's law
Archimedes' principle
Submerged and floating bodies
Measurement of densities of liquids and solids
Atmospheric pressure
Explanation: due to weight of air
Standard atmospheric pressure and its value in pounds per square inch
Measurement of atmospheric pressure by mercurial barometer; vertical height of barometric column in inches and centimeters of mercury
Boyle's law and its experimental verification

Work, power and machines

Concept of work
Units: foot pound, gram centimeter
Derivation of the principle of work (Derivation based on some machine such as a lever or an inclined plane)
Machines
Lever, wheel and axle, pulley and inclined plane
Ideal mechanical advantage
Torque or moment of force
Center of gravity
Friction and work against friction
(Coefficient of friction not required)
Mechanical advantage of machines with friction
Efficiency
Power: time rate of doing work
Units: foot pound per second; gram centimeter per second; horsepower

Force and motion

Force as a vector quantity, that is, one which has both magnitude and direction
Graphical representation of forces
Vector addition (composition) of two forces by the parallelogram method
Components of a force, graphical method
Rectangular components, graphical and numerical methods
Motions in a straight line
Constant velocity
Units: foot per second; centimeter per second; mile per hour
Average velocity
Instantaneous velocity
Constant acceleration
Units: foot per second, per second; centimeter per second, per second
Acceleration due to gravity
Newton's law of universal gravitation (qualitative only)
Newton's laws of motion
Concept of mass or inertia
Relation of acceleration, force and mass: the acceleration is proportional to the force and inversely proportional to the mass

Energy

Potential energy: energy of a position or form
Potential energy of a raised weight in foot pounds and in gram centimeters

Kinetic energy: energy of motion; kinetic energy is proportional to the mass and to the square of the velocity
Conservation of energy; transfer and transformation of energy

Temperature and Heat

Temperature and its effects
Measurement of temperature by liquid-in-glass thermometer
Temperatures scales
Fixed points and the division of the interval between them into degrees
Fahrenheit, centigrade, and Kelvin (centigrade absolute) scales
Expansion
Coefficient of linear expansion
Volume expansion of solids and liquids (qualitative)
Anomalous expansion of water
Expansion of gases
$P_1V_1/T_1 = P_2V_2/T_2$, or
$P_1V_1/(t_1+273) = P_2V_2/(t_2+273)$
Quantity of heat
Units: calory; British thermal unit
Specific heat
Measurement of specific heat by simple calorimeter
Heat as a form of energy
Mechanical equivalent of heat
Changes in state
Fusion and solidification; heat of fusion; vaporization and condensation; heat of vaporization
Boiling
Effect of pressure on boiling temperature (qualitative)
Transfer of heat (qualitative)
Conduction and convection; radiation

Sound

Sources of sound
Nature of sound waves
Speed of sound in air (approximate value)
Relation between speed, wave-length and frequency
Measurement of speed of sound by resonance

Light

Light waves carry energy
Speed of light in a vacuum and in transparent materials
Refractive index as a ratio of speeds
Propagation of light in a homogeneous medium: the light travels in straight lines
Rays and shadows
Regular and diffuse reflection
Law of regular reflection
Refraction
Path of refracted ray: a ray incident obliquely into a medium in which the speed is smaller is bent toward the normal
Refraction and dispersion by a prism
Visible spectrum
Wave-length and color
Image formation, ray treatment
Real and virtual images
Image formation by a plane mirror

Image formation by a converging lens; focal points and focal length of a lens; relation between object and image distances; application to camera and projection lantern

MAGNETISM AND ELECTRICITY

Magnetism
- Magnetic and nonmagnetic substances
- Magnetic poles: like poles repel, unlike poles attract
- Magnetic fields
  - Mapping by lines of force
  - General nature of the earth's magnetic field
- Magnetization
  - Ewing theory of molecular magnets

Electric charges at rest
- Electric charge: like charges repel, unlike charges attract
- Electrons
- Electrification by contact ("by friction")
- Induced charges
- Leaf electroscope; response when charged and uncharged
- Conductors and insulators

Charges in motion
- Current: time rate of flow of electric charge
  - Effects produced by a current: electrolytic, heating and magnetic effects
  - Unit: ampere
  - Measurement of current by galvanometer or ammeter
- Electromotive force
  - Unit: volt
  - Measurement by voltmeter
  - Primary and secondary cells as energy converters
- Resistance
  - Unit: ohm
  - Ohm's law
  - Measurement of resistance by voltmeter-ammeter method
  - Resistors connected in series and in parallel
- Magnetic effects of a current
  - Relation between the direction of the current and the direction of the lines of force around a straight wire and around a coil
  - Electromagnets
  - Simple direct-current motor
  - Galvanometer
- Chemical effects of a current; electroplating (qualitative)
  - Heating effects of a current: the time rate of heating is proportional to the resistance and to the square of the current

Power and energy
- Units of power: watt, kilowatt
- Units of energy: joule, kilowatt hour
- Computation of power: *power in watts* = *volts* × *amperes*

Electromagnetic induction
- Lenz's law
- Simple two-pole generator

PART II

The following topics are suggested as subject matter which it is desirable to include for the enrichment of a well-balanced course, but questions on these topics will not appear in the examination.

MECHANICS

Newton's second law of motion (quantitative problems); momentum; dyne, erg and joule; coefficient of friction; motion with constant acceleration when initial or final velocity is not zero; projectile motion; centripetal and centrifugal forces.

HEAT

Calorimetry involving heats of fusion and vaporization; liquefaction of gases; humdity and dew point; heat of combustion.

MAGNETISM AND ELECTRICITY

Coulomb law for electric charges; electric and magnetic field strengths; internal resistance and terminal potential difference of cells and generators, back electromotive force, transformers.

LIGHT

Snell law of refraction; telescopes and microscopes; magnification; the eye and spectacles; spherical and chromatic aberrations; intensity of point source; illumination by point source; interference; plane polarized light; additive and subtractive color mixtures.

SOUND

Pitch, loudness and quality; reflection of sound waves; interference; beats.

MOLECULAR AND ATOMIC PHYSICS

Concept of the molecule, evidence for kinetic-molecular conception of matter, approximate size of molecules, Brownian movement; Rutherford-Bohr atom, electron, proton, neutron, charge of electron; ionization, conduction in gases and electrolytes; emission of radiation by atoms and molecules; spectrum analysis; photoelectric effect, thermionic emission; x-rays.

The Board will welcome suggestions from teachers of the sciences.

The Commission on Requirements for the College Entrance Examinations in Physics and Chemistry.—JOHN T. TATE, *Chairman*, University of Minnesota; OTIS E. ALLEY, High School, Winchester, Massachusetts; RAYMOND BROWNLEE, Stuyvesant High School, New York City; JANET H. CLARK, University of Rochester; J. S. HOGG, Phillips Exeter Academy; E. B. KELSEY, Yale University; ALFRED R. LINCOLN, Technical High School, Springfield, Massachusetts; DUANE ROLLER, Hunter College; F. W. SEARS, Massachusetts Institute of Technology; MARY L. SHERRILL, Mount Holyoke College; HOWARD A. TABER, Hotchkiss School.

BOOKS RECEIVED

LIVING MATHEMATICS, by Ralph S. Underwood, *Professor of Mathematics, Texas Technological College*, and Fred W. Sparks, *Professor of Mathematics, Texas Technological College*. Cloth. Pages ix+365. 15×23 cm. 1940. The McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $3.00.

A BRIEF COURSE IN ANALYTICS, by M. A. Hill, Jr., and J. B. Linker, *University of North Carolina*. Cloth. Pages ix+204. 13×20 cm. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.36.

INTRODUCTORY BUSINESS MATHEMATICS, by Joel S. Georges, *Chairman of the Department of Mathematics, Wright Junior College, Chicago, Illinois,* and William H. Conley, *Dean of Wright Junior College, Chicago, Illinois.* Cloth. Pages x+326. 13.5×21.5 cm. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $2.40.

FUNDAMENTALS OF COLLEGE PHYSICS, by Willibald Weniger, *Professor of Physics, Oregon State College.* Cloth. Pages viii+694. 1940. American Book Company, 300 Pike Street, Cincinnati, Ohio. Price $3.75.

THE CHEMIST AT WORK, by Roy I. Grady ,and John W. Chittum, *Professors of Chemistry, College of Wooster, Wooster, Ohio,* and Others. Cloth. Pages xv+454. 12.5×20 cm. 1940. Journal of Chemical Education, 20th and Northampton Streets, Easton, Pa. Price $3.00.

GENERAL PSYCHOLOGY, by Richard Wellington Husband, *Assistant Professor of Psychology, University of Wisconsin.* Cloth. Pages xiv+513. 15×23 cm. 1940. Farrar and Rinehart, Inc., New York, N. Y. Price $2.75.

THINGS A BOY CAN DO WITH CHEMISTRY, by Alfred Morgan. Cloth. Pages xvii+288. 13×20.5 cm. 1940. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y. Price $2.50.

PRACTICAL ALGEBRA WITH GEOMETRICAL APPLICATIONS, by John H. Wolfe, *Supervisor of Apprentice School Ford Motor Company;* William F. Mueller, *Head of Mathematics Department, Ford Apprentice School;* and Seibert D. Mullikin, *Instructor of Mathematics, Ford Apprentice School.* Cloth. Pages xiii+314. 11.5×20 cm. 1940. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.20.

DYNAMICS OF INFLAMMATION, by Valy Menkin, *Department of Pathology, Harvard University Medical School.* Cloth. Pages xii+244. 14×21.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.50.

INTERMEDIATE CHEMICAL CALCULATIONS, by J. R. Partington, *Professor of Chemistry in the University of London, Queen Mary College,* and Kathleen Stratton, *Lecturer in Chemistry in Queen Mary College.* Cloth. Pages x+239. 13×20 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.65.

A COLLEGE COURSE OF INORGANIC CHEMISTRY, by J. R. Partington, *Professor of Chemistry in the University of London, Queen Mary College.* Cloth. Pages x+658. 13.5×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.50.

GILMARTIN'S WORD STUDY, by John G. Gilmartin, *Principal, Duggan and Begnal Schools, Waterbury, Connecticut.* Author of Vocabulary-Building and Practical English Course. Second Revised Edition. Cloth. Pages x+179. 12.5×18.5 cm. 1940. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price Trade: 75 cents, School: 48 cents.

CHEMICAL PUBLICATIONS, by M. G. Mellon, *Professor of Analytical Chemistry, Purdue University.* Second Edition. Cloth. Pages xii+284. 13.5×20.5 cm. 1940. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price $2.75.

BIBLIOGRAPHY OF MATHEMATICAL WORKS PRINTED IN AMERICA THROUGH 1850, by Louis C. Karpinski with the Cooperation for Washington Libraries of Walter F. Shenton. Cloth. Pages xxvi+697. 19.5×27.5

cm. 1940. University of Michigan Press, 311 Maynard Street, Ann Arbor, Michigan. Price $6.00.

A BRIEF COURSE IN TRIGONOMETRY, by David Raymond Curtiss, and Elton James Moulton, *Professors of Mathematics, Northwestern University.* Cloth. Pages viii+118+17. 14.5×22.5 cm. 1940. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.50.

EVERYDAY PROBLEMS IN MATHEMATICS, by Gilbert D. Nelson, *Head of the Department of Mathematics in Lincoln High School, Cleveland, Ohio;* Joseph M. Jacobs, *Member of Mathematics Curriculum Committee, Mathematics Curriculum Center, East High School, Cleveland, Ohio;* and Fred N. Burroughs, *Head of the Department of Mathematics in John Adams High School, Cleveland, Ohio.* Cloth. Pages viii+494+viii. 13.5×20 cm. 1940. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $1.40.

THE MATHEMATICS OF BUSINESS, by Hugh E. Stelson, *Professor of Mathematics, Kent State University.* Cloth. Pages ix+464. 13×20.5 cm. 1940. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $2.50.

THE MARCH OF MEDICINE, Edited by the Committee on Lectures to the Laity of the New York Academy of Medicine. Cloth. Pages x×168. 13×20.5 cm. 1940. Columbia University Press, Morningside Heights, New York. Price $2.00.

FUNDAMENTALS OF SEMIMICRO QUALITATIVE ANALYSIS, by Erwin B. Kelsey, and Harold G. Dietrich, *Assistant Professors in Chemistry, Yale University.* Cloth. Pages x+350. 14×21.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.75.

ELEMENTARY LABORATORY EXPERIMENTS IN ORGANIC CHEMISTRY, by Roger Adams, *Professor of Organic Chemistry in the University of Illinois,* and John R. Johnson, *Professor of Organic Chemistry in Cornell University.* Third Edition. Cloth. Pages xvi+420. 13.5×21.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

ELEMENTS OF ANALYTIC GEOMETRY, by Clyde E. Love, *Professor of Mathematics in the University of Michigan.* Second Edition. Cloth. Pages xii+159. 13×20.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.75.

THE PLACE OF MATHEMATICS IN SECONDARY EDUCATION. Final Report of the Joint Commission of the Mathematical Association of America and the National Council of Teachers of Mathematics. Fifteenth Yearbook. 1940. Cloth. Pages xvi+253. 14.5×23 cm. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.25.

ROUND THE WORLD IN INDUSTRY, by Gerald Collins. Cloth. Pages xi+180. 13.5×22 cm. 1940. The Chemical Publishing Company, Inc., 148 Lafayette Street, New York, N. Y. Price $2.00.

THE PHYSICAL SCIENCES, by Emmett James Cable, *Head of the Science Department;* Robert Ward Getchell, *Professor of Chemistry;* and William Henry Kadesch, *Professor of Physics, Iowa State Teachers College.* Cloth. Pages xvii+754. 14.5×23 cm. 1940. Prentice-Hall, Inc, 70 Fifth Avenue, New York, N. Y. Price Trade: $5.00, School: $3.75.

METRIC DIFFERENTIAL GEOMETRY OF CURVES AND SURFACES, by Ernest Preston Lane, *Professor of Mathematics in the University of Chicago, Chi-*

cago, Illinois. Cloth. Pages viii+216. 15×23 cm. 1940. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $3.00.

EVERYDAY PROBLEMS IN SCIENCE, by Wilbur L. Beauchamp, *University of Chicago;* John C. Mayfield, *University High School, Chicago;* and Joe Young West, *Maryland State Teachers College.* Cloth. Pages xvi+752. 14×22.5 cm. 1940. Scott, Foresman and Company, 623 South Wabash Avenue, Chicago, Ill. Price $1.72.

AN INTRODUCTION TO ANALYTICAL GEOMETRY, by A. Robson, *Senior Mathematical Master at Marlborough College.* Volume I. Cloth. Pages xiv +409. 12.5×22 cm. 1940. The Macmillan Company 60 Fifth Avenue, New York, N. Y. Price $2.50.

FUNDAMENTALS OF PHOTOGRAPHY, by Paul E. Boucher, *Professor of Physics, The Colorado College.* Cloth. Pages xi+304+li. 15×23 cm. 1940. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.00.

PRACTICAL MATHEMATICS, Part I—Arithmetic with Applications, by Claude Irwin Palmer, *Late Professor of Mathematics and Dean of Students, Armour Institute of Technology,* and Samuel Fletcher Bibb, *Associate Professor of Mathematics, Armour Institute of Technology.* Fourth Edition. Cloth. Pages xii+186. 11.5×17.5 cm. 1940. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.25.

A COLLEGE TEXTBOOK OF HYGIENE, by Dean Franklin Smiley, *Medical Adviser and Professor of Hygiene in Cornell University,* and Adrian Gordon Gould, *Assistant Medical Adviser and Assistant Professor of Hygiene in Cornell University.* Third Edition. Cloth. Pages xiii+539. 14×21.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.50.

THE THEORY OF GROUP CHARACTERS AND MATRIX REPRESENTATIONS OF GROUPS, by Dudley E. Littlewood. Cloth. Pages viii+292. 16×24 cm. 1940. Oxford University Press, 114 Fifth Avenue, New York, N. Y. Price $5.50.

UNDERSTANDING RADIO, by Herbert M. Watson, *Associate Member I. R. E.;* Herbert E. Welch, *Associate Professor of Radio Technology and Engineering, Stockton Junior College, Stockton, California;* and George S. Eby, *Professor of Applied Science, Stockton Junior College, Stockton, California.* Cloth. Pages ix+603. 13.5×20.5 cm. 1940. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.80.

THE MATHEMATICAL PAPERS OF SIR WILLIAM ROWAN HAMILTON, Volume II—Dynamics. Edited for the Royal Irish Academy, by A. W. Conway, *Professor of Mathematical Physics, University College, Dublin,* and A. J. McConnell, *Fellow and University Professor of Natural Philosophy, Trinity College, Dublin.* Cloth. Pages xv+656. 22×30 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $19.50.

ANIMALS IN ACTION, by Gayle Pickwell, *Professor of Zoology at San José State College, San José, California.* Cloth. Pages xii+190. 21.5×29 cm. 1940. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $4.00.

ELEMENTS OF BOTANY, by Richard M. Holman, *Late Associate Professor of Botany in the College of Letters and Science of the University of California,* and Wilfred W. Robbins, *Professor of Botany in the College of Agriculture*

of the University of California. Third Edition. Cloth. Pages xi+392. 14.5 ×23 cm. 1940. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.75.

PLANE GEOMETRY, by A. M. Welchons and W. R. Krickenberger, *The Arsenal Technical High School, Indianapolis, Indiana.* Revised Edition. Cloth. Pages x+502. 13×20 cm. 1940. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.40.

PLANE AND SPHERICAL TRIGONOMETRY, by Lyman M. Kells, *Associate Professor of Mathematics;* Willis F. Kern, *Assistant Professor of Mathematics;* and James R. Bland, *Associate Professor of Mathematics, all at the United States Naval Academy.* Second Edition. Cloth. Pages xv+401. 14.5×23 cm. 1940. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.00.

LIVING THINGS AND YOU by Elliot R. Downing, *Associate Professor Emeritus of the Teaching of Science, University of Chicago,* and Veva M. McAtee, *Head, Department of Science, George Roger Clark High School, Hammond, Indiana.* Cloth. Pages xxv+673. 13×20.5 cm. 1940. Lyns and Carnahan, 2500 Prairie Avenue, Chicago, Ill.

THE STORY OF SUPERFINISH, by Arthur M. Swigert, Jr., *Director of Production Research for Chrysler Division.* Cloth. 672 pages. 15×23 cm. 1940. Chrysler Corporation, Chrysler Sales Division, Detroit, Mich.

NEW TREND GEOMETRY, by Adele Leonhardy, *Department of Mathematics, Shorewood High School, Shorewood, Wisconsin;* Margaret Joseph, *Department of Mathematics, Shorewood High School, Shorewood, Wisconsin;* and Ralph D. McLeary, *Director of Mathematics, Brookline Public Schools, Brookline, Massachusetts.* Cloth. Pages xi+494. 12.5×19.5 cm. 1940. Charles E. Merrill Company, 381 Fourth Avenue, New York, N. Y.

BOOK REVIEWS

AN AIR-CONDITIONING PRIMER, by William Hull Stangle, *Forest Hills New York.* Cloth. Pages vii+236. 15×23 cm. 1940. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.50.

Air conditioning has been thoroughly publicized for a number of years but much has been said and written that is erroneous, some things that are intentionally misleading. Much of what has reached the average citizen has been misunderstood. A business to which the public contributes millions of dollars annually deserves scientific study. Those who pay the bill should understand what they are paying for.

This book is written for the average business man and householder. Part I explains the elementary principles of heating, insulating, ventilating, and moisture control, and how health and comfort are affected by variations in such physical conditions. Part II gives a satisfactory discussion of the apparatus now available for heating and air conditioning all types of buildings. The information given is reliable and readable. The book is suitable for use as a text for an elementary course.

G. W. W.

MATHEMATICAL CLUBS AND RECREATIONS, by Samuel I. Jones, Author of *Mathematical Nuts and Mathematical Wrinkles.* Formerly *Professor of Mathematics, David Lipscomb College and Assistant Secretary and Treas-*

urer of Life and Casually Insurance Company, Nashville, Tennessee. Half Leather. Pages xiv+236. 12.5×18.5 cm. 1940. S. I. Jones Company, 1122 Belvidere Drive, Nashville, Tenn. Price $2.75.

This is the third of a series of books by Mr. Jones designed to supply the demand for interesting puzzles, problems, games, etc. of a mathematical nature. Part I gives just the information needed by the teacher who must organize and sponsor a mathematics club in junior or senior high school. It discusses aims, organization, historical development, activities, and benefits of such clubs, even including "By-Laws" of several successful clubs. Part II, which is headed "Recreation," presents a host of amusements, brain teasers, curious tables, games, fallacies, magic squares, etc. of all degrees of difficulty. A discussion of a perpetual calendar and a series of Bible tests are included. Part III gives the answers and solutions. In general the book is trustworthy, but like all earthly products there must be some exceptions. Here is one to raise the physicists' ire: Page 108, No. 4; "If the thermometer registers zero what will it register if it gets twice as cold?" Answer on page 223; "32°F. below zero." But like its companion books, *Mathematical Wrinkles* and *Mathematical Nuts, Mathematical Clubs and Recreations* will be a true friend of the teacher and a joy to students.

G. W. W.

THE SECONDARY SCHOOL, by Charles Watters Odell, Ph.D., *Associate Professor of Education, University of Illinois.* Cloth. Pages viii+606. 13×22 cm. 1939. The Garard Press, Champaign, Illinois. Price $3.00.

This book is an excellent treatise on the secondary school and should prove of great value to one seeking information concerning education at this level. Although the author states that his purpose is to present facts and viewpoints relative to the secondary school that will be helpful to those who are preparing to become secondary school teachers in this country, the book can be used as a source of information by those seeking a comprehensive knowledge of that institution, including both its development and present status.

The chief topics or phases of secondary education treated in the volume are its history and development, both in the United States and elsewhere; its relationship to the school system below and above it; its objectives or functions; curriculum construction; pupils, particularly their individual differences and the characteristics of adolescence; guidance, educational, vocational, personal and whatever else it may be; the teacher; and certain phases of organization, administration, and public relations.

In discussing the secondary school of today the author not only gives a picture of present conditions, but tells how they came about. The present status is criticized and desirable modifications are suggested. Thus he endeavors to lead the reader to critical reflective thinking concerning the problems of secondary education and to the development of attitudes and ideals applicable to the whole school system in general and to the secondary school in particular. This book is indeed a valuable contribution to the literature of education.

CHARLES A. STONE

AMERICAN MAMMALS, THEIR LIVES, HABITS AND ECONOMIC RELATIONSHIPS, by W. J. Hamilton Jr., *Cornell University.* Cloth. Pages xii+434. 16×23.5 cm. 92 illustrations. 1939. McGraw-Hill Book Co., Inc., New York, $3.75.

A very interesting addition to the works on the study of Mammalogy. It is a treatise on all the families of North American Mammals from Panama to the Arctic Barrens. Certain details of the habits of these animals are portrayed here for the first time. This book with its detailed discussion rounds out somewhat the literature on the North American Mammals. Up to now this material existed only in isolated reports and works on restricted areas mainly State areas. Of the myriad of interesting data presented we mention an item about the size of arctic mammalian genera compared with the size of their relatives in the south. The sizes of the Arctic members are greater. The ecological reason for this is nicely explained. The chapter headings give an idea of the scope of the work The Chapters are on: The Ancestry of Mammals. Classification. Some Characters of Mammals and Their Uses. Adaptations. Storage of Food. Reproduction and Early Life. The Home of Mammals. Hibernation. Migration. Mammal Population. Behaviour. Distribution. Useful Mammals. Injurious Mammals. Game Mammals. Fur-Bearing Mammals. Predatory Mammals. A comprehensive index is appended. This matter of index is important in a book such as this which is to be used largely as a reference. The mechanical makeup is very well done as is usual with this publishing house.

A. G. ZANDER

A BRIEF COURSE IN TRIGONOMETRY, by David Raymond Curtiss and Elton James Moulton, *Professors of Mathematics, Northwestern University*. Cloth. Pages viii+118+17 pages of tables. 15×22 cm. 1940. D. C. Heath and Co., Boston, Mass. Price $1.50.

At first glance one might doubt whether such a small volume could possibly contain sufficient material for a college course. The text has been written particularly for the two semester hour or three quarter hour course and with this in mind several topics frequently presented are omitted, for example, spherical trigonometry, Demoivre's theorem. Four place tables are used, with the problems designed to use such tables.

The treatment starts with the general angle, including an interesting presentation involving polar coordinates. Solution of triangles is the last topic treated. There is a large number of exercises, with answers provided to the odd numbered ones. Although the authors point out that five or six place tables are available for the instructor who wishes to use them, it seems likely he would also need to furnish problems which would call for the use of such tables. The student reading this text would never discover that other authorities might disagree as to the definition of the principal values of some of the inverse functions.

The book has a pleasing appearance and it would appear to be a good text for shorter courses for which it is planned. One trivial misprint was noted in the first page of the preface.

CECIL B. READ
University of Wichita

EXERCISES IN REASONING, by Joseph A. Nyberg, *Hyde Park High School, Chicago, Illinois*. Paper. 84 pages. 21×28 cm. 1940. Joseph A. Nyberg, 10505 S. Bell Avenue, Chicago, Ill. Single copies 50 cents, 10 or more 30 cents each.

Ever since educators began to doubt that training in one subject was automatically transferred to any other subject in which one had occasion to use it there has been a growing feeling that we should deliberately plan for any transfer that we hoped to achieve. This idea has lately been work-

ing itself out in geometry in the form of the introduction of exercises unrelated to mathematics except in the use of the same general principles of reasoning. For example, "I know Mr. Level is a graduate of Harvard University. Therefore I know he belongs to the H-Y-P Club because only graduates of Harvard, Yale and Princeton may belong to this club. Discuss this reasoning." Some texts in geometry have two or three pages of exercises in reasoning such as this; a few have more; many have none. Shall we leave out such materials as this, or shall we include more, or shall we find something better suited to the purpose, or shall we give more systematic treatment of the principles of reasoning involved? Probably no one knows or pretends to know the answers to these and many like questions. Certainly it is not to be contended that the situation as represented in present texts is the ideal one. Some serious study of the problem is evidently needed.

In *Exercises in Reasoning*, Mr. Nyberg has given more serious consideration to this problem than any author whose work has come to our attention. The difference between assumptions and other statements is carefully illustrated and discussed and questions are listed to give the pupil experience in using both assumptions and supported statements in reasoning. There follows a good discussion of general statements and hasty generalizations and practice in the correct use of generalization. Then comes a treatment of the use of hypothesis and conclusion, and the building up of a proof; at this point the discussion has but little to do with mathematics. In Chapter 4 the author discusses geometric proofs as a specific application of the general principles of reasoning. Chapter 9 deals with necessary and sufficient conditions. Chapter 10 is on inductive and deductive methods of reasoning with emphasis again on other than mathematical situations. Arguing in circles, drawing conclusions without sufficient data, ad hominem argument, poo-pooing the question and other such arguments are given treatment, always with provision for the pupil to practice his knowledge on problems given in the book. There is a whole chapter on propaganda; it would seem that this one chapter would justify the little volume. In these days when the fate of nations is being determined by propaganda, good and bad, it would seem that people must be educated on propaganda interpretation and consumption.

Mr. Nyberg is to be commended for having pioneered in this interesting field, and for having done his work so thoroughly. Just where the material is to be used is not clear, but if we subscribe to the principle that what is worth doing is worth doing well, we must regard this book as having a place in the schools, provided, of course, we accept it as our obligation to teach the principles of reasoning in other than mathematical situations.

WALTER H. CARNAHAN
Shortridge High School
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CALCULUS, by Charles K. Robbins, and Neil Little, *Purdue University*. Cloth. Pages viii+398. 15×23 cm. 1940. The Macmillan Company, New York, N. Y. Price $3.25.

The general content of this text is largely that of the traditional college course in calculus. In the presentation of the material the authors immediately introduce the student to the concept of the derivative, presenting topics such as a discussion of limits and other material frequently encountered in the first chapter at later intervals throughout the book. In this presentation, it becomes obvious that a rigorous mathematical definition of some concepts must be presented following a discussion and use of

material which is introduced somewhat informally. Where rigorous definitions are not given, one frequently finds reference to later sections, or to other reference books—how many students will consult such references is somewhat problematical. In many cases a concept is presented as if the student were thoroughly familiar with the terms used, yet a footnote gives a definition for the benefit of the student whose memory fails him.

It seems quite probable that the method of presenting material would be very effective. There is an ample supply of problems, with a rather wide range of difficulty. In the back of the book one finds useful tables, including trigonometric functions, natural logarithms, exponentials and hyperbolic functions, as well as the customary formulas from geometry and trigonometry.

The beginning student is very likely to become confused by the use of the term *pressure* as synonymous with *force* or *weight*. At one place it is by no means clear that unit area enters into the concept of pressure.

CECIL B. READ
University of Wichita

INTRODUCTORY BUSINESS MATHEMATICS, by Joel S. Georges, *Chairman of the Department of Mathematics, Wright Junior College*, and William H. Conley, *Dean of Wright Junior College*. Cloth. Pages x+326. 14×21.5 cm. 1940. Henry Holt and Company, New York, N. Y. Price $2.40.

The authors point out that this text is written for the large group of students in the business department of a junior college who do not plan to continue their education in a senior college. The material covered varies widely in difficulty, the introductory material covered in the first third of the text is to a large part identical with that to be found in several texts written for freshman high school students. At the other extreme one finds some rather difficult problems in nomography.

The problem material seems well selected, and in general the problems are of a practical nature (in one case, to change 5000″ to degrees, minutes, and seconds, there might be valid criticism). In some parts of the text the supply of problems is rather scant.

Many of the problems cover material which the student is likely to encounter in business, and from this point of view the text ought to satisfy many of the critics of the conventional course content. From the other point of view one might encounter the objection that the treatment is by formalized rules, with little incentive for thought on the part of the student; follow the rule and the result is obtained—just what happens if there is no rule to cover is problematical.

The discussion of approximate numbers is very brief; some might question the terminology used in calling $0.3\frac{1}{3}$ and similar expressions exact decimals; defining class intervals of a frequency distribution as 50–55 and 55–60 with the provision that 55 belongs to the class 50–55 with the *mean measure* of the class 53 is not in agreement with the majority of statistics texts; discussion of the use of an ordinary protractor for construction of a circle graph seems inefficient when percentage protractors are available; it seems unusual not to mention the method of least squares in the treatment of curve fitting. But these are minor details regarding which there may well be difference of opinion. Considered as a preparatory text for more advanced work in business mathematics, the text seems to offer many possibilities to those interested.

CECIL B. READ
University of Wichita

COLLEGE ALGEBRA, by Lewis M. Reagan, *Assistant Professor of Mathmatics, Polytechnic Institute of Brooklyn;* Ellis R. Ott, *Assistant Professor fessor of Mathematics University of Buffalo;* and Daniel T. Sigley, *Assistant Professor of Mathematics, Kansas State College.* Cloth. Pages xviii+445. 13.5×20.5 cm. 1940. Farrar and Einehart, Inc., New York, N. Y. Price $2.50.

Perhaps the most striking feature of this book is the marked rearrangement in the order of topics, as contrasted with the usual text. To illustrate: permutations, combinations, probability, the binomial theorem, series, logarithms,—all these precede the treatment of factorization and of quadratic equations. Ratio, proportion, and variation appear almost at the end of the book.

In several cases extreme care was used in the introduction of new concepts, for example: when introducing zero as an exponent it is pointed out that 0^0 is undefined; in the treatment of limits for the roots of an equation by use of the signs in the third row of synthetic division of $f(x)$ by $x-a$ it is clearly pointed out that this method may not give a *least* upper limit. Unfortunately, this careful treatment is not always found: the possible difficulties in the treatment of $a^{m/n}$ when a is negative and n even are not clearly pointed out; it is not made clear whether or not zero is a pure imaginary number.

Several topics appear, with more or less detailed treatment, which are not customarily found in a college algebra: in the discussion of graphing equations there is a brief outline of the treatment of symmetry and of extent, such as found in most analytical geometry texts; there is extended treatment of deductive and inductive reasoning, including a discussion of necessary and sufficient conditions; the summation notation is introduced early in the book; the method of undetermined coefficients is used several times, as in finding the sum of a series; well drawn graphs of several of the common types of higher plane curves are given for reference; the general solution of $n-1$ homogeneous linear equations in n unknowns is written by use of a matrix; Diophantine equations are treated in some detail; there is a treatment of infinite continued fractions as well as rather extended treatment of partial fractions.

In many places explanations are given in more detail than is customary, in fact, one might almost imagine the presence of a good teacher in the class room when reading the text. Unfortunately, in some cases the supply of problem material seems hardly adequate if the text is to be used for several years.

Although the treatment is so unusual as to require rather careful analysis, the text seems definitely not a freak, in fact, it would be a very interesting experiment to compare it in use as contrasted with the conventional text.

CECIL B. READ
University of Wichita

STEPHEN BRADFORD DAVOL

1874–1940

We regret to announce the death on August 27, 1940, of our associate, STEPHEN BRADFORD DAVOL, *for over forty-four years connected with this Company, and a director from the incorporation of the business thirty-two years ago.*

HOUGHTON MIFFLIN COMPANY

AMERICAN EDUCATION WEEK STRESSES THE COMMON DEFENSE

"Education for the Common Defense" is the general theme for the twentieth annual observance of American Education Week, November 10–16, 1940. No theme could be more appropriate to the present period. This occasion offers an unparalleled opportunity to interpret the contribution of the schools to the common defense of the American way of life.

The daily topics for the observance are:

Sunday, November 10—Enriching Spiritual Life
Monday, November 11—Strengthening Civic Loyalties
Tuesday, November 12—Financing Public Education
Wednesday, November 13—Developing Human Resources
Thursday, November 14—Safeguarding Natural Resources
Friday, November 15—Perpetuating Individual Liberties
Saturday, November 16—Building Economic Security

The National Education Association has prepared materials to assist schools and communities in the observance including a 32-page handbook of American Education Week technics, a 32-page booklet entitled, "Education for the Common Defense" every second page of which consists of cartoon illustrations, a poster, a leaflet for distribution to homes, a sticker, a series of eight-page folders giving specific suggestions on the various topics for different school levels, and combination packets of these materials for the different school levels.

Address the National Education Association, 1201 Sixteenth Street, N.W., Washington, D. C., for complete information regarding American Education Week materials available at low cost prices.

EDUCATING YOUTH TO MEET NATIONAL PROBLEMS

In view of the need for a broader and more thorough civic education for youth and of the demands of the workaday world for more maturity on the part of young people entering upon employment for the first time, we must plan for an upward extension of secondary education to include the thirteenth and fourteenth grades with a strong emphasis on vocational courses which will terminate not later than the age of approximately 20 years. Secondary schools should also become the centers for a vital program of adult education.

An edequate program of education for youth requires the provision of means by which *all* young people up to 20 years of age may be enabled to maintain themselves in situations where modern and complete training opportunities are available for *all* of the kinds of work which our society needs done.

Above all. we must help young people to catch the vision of a democratic society in which the contribution of each of its members in service and in sacrifice is needed in helping to build for that fairer tomorrow in which the ideals of the fathers and the faith of multitudes of toiling, freedom-loving men and women will be vindicated and fulfilled.—*From an Address by John W. Studebaker at the NEA Convention at Milwaukee, July 3, 1940.*

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.